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SPECIAL STATISTICAL SUMMARY

Deaths, Injuries, and Property Loss by Type of Disaster 1970-1980

WORK UNIT: 9511A

FEDERAL EMERGENCY MANAGEMENT AGENCY

APRIL 1982

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) Special Statistical Summary - Deaths, Injuries, and Property Loss by Type of Disaster 1970-1980	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Paula D. Gordon	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Work Unit 9511A
11. CONTROLLING OFFICE NAME AND ADDRESS Federal Emergency Management Agency Washington, D.C. 20472	12. REPORT DATE April 1982
	13. NUMBER OF PAGES 119
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

State and national emergency incident trends; catastrophic accidents; natural hazards; technological hazards; deaths, injuries, and property losses; dwellings destroyed; disaster assistance; hurricanes; tornadoes; wind storms; winter storms; floods; fires; explosions; transportation-related disasters; earthquakes; disaster impact data, statistics, and estimates.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report provides a summary of the best available statistics and estimates bearing on deaths, injuries and property damage which have occurred over the past ten years as a result of a broad spectrum of disasters. Included in the summary are American National Red Cross statistics which bear on deaths, injuries and property loss. (Property losses are not computed in dollar terms, but in number of dwellings destroyed.) Also included is a compilation of FEMA outlays for a full range of Presidentially-declared major disasters and emergencies during the period 1970-1980.

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PREFACE

This report was written in response to a recognized need on the part of those involved in making policy and establishing priorities relating to information and estimates concerning the deaths, injuries, and property damage that have occurred in recent years as a result of a wide range of disasters.

The review reveals that both a great diversity of information and a wide variety of sources exist. This summary is expected to serve a useful purpose in pulling together in one place major recent sources of disaster impact data. The preparation of the summary has also served to highlight existing inadequacies with respect to the gathering and uses of such data. Recommendations from various sources addressing the compilation and use of disaster impact data appear in the document and in the appendices.

The work was undertaken by the National Preparedness Programs Directorate of the Federal Emergency Management Agency (FEMA). Compilation and writing was done by Dr. Paula D. Gordon, a consultant to FEMA.

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1. OVERVIEW AND RECOMMENDATIONS

Nature and Content of Summary

The following provides a summary of the best available statistics and estimates bearing on deaths, injuries, and property damage which have occurred over the past ten years as a result of a broad spectrum of disasters.[1] Some projections are also included concerning deaths and losses expected in the year 2000.

In Section 2 American National Red Cross statistics are cited which bear on deaths, injuries and property loss. (Property losses are not computed in dollar terms, but in number of dwellings destroyed.)

Section 3 is a compilation of FEMA outlays for a full range of Presidentially-declared major disasters and emergencies during the period 1970-1980.

Data and estimates used in the J.H. Wiggins Company study, Natural Hazards - A Public Policy Assessment (Petak et al., 1978) are provided in Section 4. These focus on dollar losses resulting from a variety of factors, including building damage, contents damage, and income loss and on number of deaths and other losses.

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[1]The Disaster Victimization Study presently underway at the University of Massachusetts, conducted by Peter H. Rossi and James D. Wright, has not been made a part of this summary. Data collection involving a national household survey to provide national estimates of the injuries and damages to households sustained through a range of disasters was completed on November 2, 1981. Preliminary analysis of t e data will be available in April of 1982.

Figures focussing on overall economic losses based in part on subjective judgments and in part on documentation are provided in Section 5. These figures have been extrapolated from compilations done by D. Earl Jones of the Department of Housing and Urban Development.[1] A summary of economic losses by type of disaster is presented along with more fully detailed tables. The first details coarse estimates of annual natural hazard losses. The second table provides a rank ordering of natural hazards by estimated magnitude of average annual losses.

Additional material related to statistics concerned with death, injury and property losses resulting from disasters is provided in the appendices.

Statistics Used

A variety of sources of death statistics exist. It is the view of some persons who are experts in the disaster field that the most reliable comprehensive death statistics (although by no means complete) are those compiled by the American National Red Cross.

With respect to statistics concerning injuries and illnesses resulting from disasters, the data of the Red Cross are once again widely viewed as being most complete. E.L. Quarantelli of the Disaster Research Center, Ohio State University, has found repeatedly, however, that Red Cross statistics for

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[1]This material was presented by Jones at the April 30-May 1, 1981 meeting of the Committee on Emergency Management of the Commission on Sociotechnical Systems, National Research Council (D. Earl Jones, 1981.)

injuries tend to be on the low side. When more thorough follow-up studies have been undertaken, this researcher has found that injury figures can consistently be multiplied by a factor of 2, 3, or 4 to obtain a truer count.[1]

Determining or projecting costs and losses of an economic character tends to be even more inexact. In fact such determinations tend to be highly problematic at best. As J.K. Mitchell has pointed out:

> Damage estimates are subject to a variety of errors and problems of interpretation. Individual assessors utilize varying loss criteria. (Mitchell, 1974)

For these reasons, it is impossible to make clear comparisons between data. Examples of data, estimates, and projections which reflect attention to different factors include the following:

- o Insurance company data which tend to be limited to insured and/or insurable property;[2]
- o Red Cross data which are limited to areas served during disasters;
- o Certain mortality data which are limited to information available on death certificates.

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[1]Phone conversation with E.L. Quarantelli, October 29, 1981.

[2]Data completed by the Metropolitan Life Insurance Company are a major exception. Two tables are included as Appendices A and B. In Appendix A numbers of catastrophic accidents and deaths are indicated by the type of accident in the United States, 1941-75. In Appendix B deaths resulting from major catastrophes occurring between 1976-80 in the United States are shown. The first table includes accidents in which five or more persons were killed. The second table includes accidents in which twenty-five or more persons were killed.

As Mitchell has also noted:

> Strikingly different estimates of loss can be achieved by varying the economic assumptions upon which the evaluations are based. (Mitchell, 1974)

Other Methodological Constraints

It should also be noted that differences in the defining of disaster categories make it difficult to draw easy comparisons of data. Differences in the time frame for which the data are collected, and the purposes for which they are collected, compound problems in comparative analysis and can render such attempts at analysis fruitless exercises. No attempt has been made to compare the data, estimates, and projections emanating from different sources which have been cited. However, observations concerning these data, estimates, and projections are provided here.

Observations and Conclusions

Statistics cited in Section 2 are drawn from the Annual Summaries of Disaster Services Activities, 1969-1980, of the American National Red Cross.[1] These statistics pertain only to those disasters in which the Red Cross was involved. Death statistics tend to be extremely reliable, while injuries tend to be underreported. Property loss data is limited solely to number of dwellings, mobile homes, apartments, and condominiums destroyed or damaged.

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[1]See Appendix C.

As a point of information and by way of illustrating the differences that can be found in sets of data pertaining to the same general type of disaster, it bears noting that with respect to fire, the American Red Cross data concerning deaths, injuries, and property loss are at sharp variance in most cases with data estimates compiled by the Fire Administration. (See Tables 1-1 and 1-2.)[1] The reason for this variance is that American Red Cross data address a limited portion of the spectrum of fire-related disasters and events while Fire Administration data focus on the full spectrum of fire-related disasters and events. The focus of the American Red Cross data reported here is limited to selected fire-related disasters in which the Red Cross plays a major role, while the Fire Administration has no such limitation; and Red Cross property loss data cited here are limited to dwellings, while Fire Administration property loss estimates include the full range of types of property destroyed, as well as vehicles destroyed.

Data concerning FEMA outlays for fire suppression assistance and for Federally-declared disasters or emergencies involving fire are shown in Table 1-3 for fiscal years 1977-1980. These data provide one indicator, albeit it a weak one, of the costs incurred as a result of large-scale fires.

FEMA outlay statistics for Federally-declared disasters and emergencies, and for fire suppression assistance for the fiscal years 1970-1980 are provided

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[1]Because of changes in 1977 in the manner in which the Fire Administration makes its data estimates, only data since that date are included in these tables. Data sources currently drawn upon by the Fire Administration and methods now being used are described briefly in Appendix A which begins on page 7-47.

in Section 3. Complete data covering the same ten-year period concerning outlays by all federal agencies for these and all other types of disasters and emergencies do not appear to be readily available.[1] The compilation of such data might be of interest in the future as a major indicator of past national impacts and previous Federal involvement in a full range of disasters, emergencies, and fire suppression activities.

The figures in the Wiggins report which are cited in Section 4 are projections. The figures in Section 5 are "coarse" estimates based in part in documentation and in part in subjective judgment. They are provided here because of their interest and to give some indication of 1) the range of projections and estimates available, and 2) some of the different ways in which losses can be viewed.

For added contrast, a table developed by the National Governor's Association indicating state emergency incidents trends has been included as Appendix E.

The reporting collecting, analyzing, or interpreting of data concerning deaths, injuries, and property damage resulting from a full spectrum of disasters tends to be done by different institutions and agencies for different purposes, using differing methodologies and criteria for data selection, with differing factors and assumptions in mind.

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[1]At the present time inquiries must be made of each individual agency. There is not one single repository where all such information can be accessed.

Following from the development of this summary and the discussions with persons knowledgeable in the hazards field upon which the summary was based, a most obvious conclusion is that there is a need for a standardization of procedures for collecting data. The need has been recognized by several persons for the establishment of an institutional capability (within or outside of FEMA) which would have as its focus the collecting of data concerning the range of hazards phenomena.

Recommendations bearing on this were made in a Workshop on Natural Hazard Data Resources held in Denver in April 1978. The Federal Disaster Assistance Administration (FDAA), a predecessor agency to FEMA, had begun acting on one of the recommendations, but the effort was never brought to a useful conclusion.[1] While this effort pertained to the collection of natural hazards data, FEMA's wider responsibilities would seem to require more broadly defined data collection efforts which would be in keeping with its mandate.

Other efforts to evolve greater standardization of data collection procedures have been made by the National Governors' Association. A form which has been developed by the NGA for states to use in reporting on emergencies is included here as Appendix D. If state officials collected such information as a matter of course using standardized collection procedures, the resulting data could be readily compared.

[1]A paper on this subject by Rossi et al. was presented at this workshop and is included in Appendix F. The paper includes useful insights into ways in natural disaster data bases can be improved.

Until such time that a standardization of data reporting, collecting and related methodological procedures come into being, it will remain a difficult, if not impossible and fruitless task, to attempt to compare data concerning deaths, injuries, and property losses pertaining to one type of disaster with data pertaining to another or all other types of disasters or to compare data gathered during one period of time with data gathered at another period. Until then, existing data sources must suffice.

In determining which source or sources of data to use, the purposes which the data are to serve need to be fully considered. If data are sought for comparison purposes, such as deriving a sense of the relative gravity of the losses resulting from different types of disasters in the U.S., then the Red Cross data provide a good sense of those relative differences. If the concern is with only those disasters and emergencies which have the greatest large scale societal impacts, then a selective searching and compilation of Red Cross data may be required. Since Red Cross data collection procedures have long been standardized nationwide, these data remain the best available indicator of the relative losses accruing from larger disasters and emergencies.

If data are sought concerning one type of disaster only, then it may be necessary to go to other data sources to get figures best suited to the concerns and scope of responsibility of the Agency.[1]

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[1]Current best sources of data are identified in Natural Hazards Data Resources-Uses and Needs edited by Susan K. Tubbesing. See Appendix G for pertinent excerpt.

In view of the difficulties which have been pointed out here, it seems especially important that steps be explored which might be taken to improve FEMA's ability to meet the Agency's data needs. Efforts which are presently being jointly undertaken by the FEMA Information Resources Management Office and the Program Analysis and Evaluation Office can be seen as an important step in this direction. It is important that such efforts include a concern for improving the consistency of data reporting, collecting, and related methodological procedures as these relate to deaths, injuries, and property losses. While there certainly would be benefits for researchers, the principal objective would be to provide better data leading to an improved basis for decisionmaking and priority setting by FEMA as well as by other agencies with disaster-related responsibilities [1]

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[1]Recommendations are provided in Natural Hazards Data Resources-Uses and Needs which focus on steps which could be taken to improve data bases, accessibility to existing data bases, and facilitation of their use. (See Appendix I.)

Table 1-1. American Red Cross Data - Deaths, Injuries, Dwellings Destroyed by Fire, and Number of Fires, FY 1977-1980 (July 1 to June 30 fiscal year)[1]

	1976-77	1977-78	1978-79	1979-80
Deaths	416	331	270	218
Injuries	1,092	1,135	876	696
Dwellings Destroyed	4,194	4,869	5,121	5,252
Number of Fires	800	1,031	2,097	3,092

Table 1-2. Fire Administration Data - Deaths, Injuries, Property Losses, Number of Fires, Calendar Years 1977-1980

	1977[2]	1978[3]	1979[4]	1980[5]
Deaths	8,516	8,100	7,800	7,600
Injuries	34,064	32,000	30,868	28,068
Property Losses (in thousands)	$4,558,517	$4,650,000	$5,551,517	$5,923,813
Numbers of Fires[6]	2,957,944	2,690,000	2,734,074	2,894,517

[1] American Red Cross Disaster Relief Reports
[2] Fire in the United States, 2nd edition (in press)
[3] Ibid.
[4] Fire in the United States, 3rd edition (forthcoming)
[5] Ibid.
[6] This includes structures, vehicles, and outside fires. This does not include all fires. There are indications that unreported fires, if counted, could increase Fire Administration estimates of incidents of fire by a factor of ten. (1974 National Household Fire Survey - same estimate used for 1977 and 1978.)

Table 1-3. FEMA Outlays for Fire Suppression Assistance and Fire-Related Federally Declared Disasters and Emergencies, FY 1977-1980 (October 1 to September 30)

OUTLAYS	FISCAL YEAR			
	1977	1978	1979	1980
Fire Suppression Assistance	$4,721,455(6)	$202,993(2)	$767,166(5)	$27,926(2)
Major Disasters and Emergencies (Fire-Related)	-0-	-0-	$1,807,827(1)	-0-
Total	$4,721,455	$202,993	$2,524,993	$27,926

NOTE: Numbers in parentheses indicate number of incidents.

2. AMERICAN RED CROSS STATISTICS on DEATHS, INJURIES, AND PROPERTY LOSSES BY TYPE of DISASTERS

Red Cross statistics cited here have been gathered by fiscal year (July 1-June 30).[1] It should be noted that these statistics reflect only selected larger disasters and emergencies in which the Red Cross was involved. Statistics concerning other disasters are not included. Nonetheless, the data provide the most complete and reliable accounting available from a single source. The same standardized methods of gathering data have been employed in all disasters for which statistics have been obtained.

As noted in the Section 1, American National Red Cross death statistics tend to be extremely reliable. Injury statistics have, however, been shown to be on the low side in numerous follow-up case studies focussing on selected disasters, e.g., Xenia disaster-related injuries turned out to be four times Red Cross figures.[2]

Property loss data is limited here solely to number of dwellings, mobile homes, apartments, and condominums destroyed. No monetary value has been assigned or determined.

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[1] More detailed Red Cross statistics are to be found in Appendix C.
[2] Phone conversation with E.L. Quarantelli, op. cit.

Table 2-1. Summary: American Red Cross Data - Deaths, Injuries, Dwellings Destroyed (All Disasters) Totals, 1970-1980

	Ten Year Total	Annual Average
Deaths	7,169	717
Injuries	105,159	10,516
Dwellings Destroyed	100,363	10,036

Note: All statistics cited here are drawn directly from or based upon statistics cited in the Annual Disaster Relief Reports of the American Red Cross. More detailed summaries of this data are to be found in Appendix C.

Table 2-2 Summary: American Red Cross Data - Deaths by Type of Disaster, 1970-80

	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77	77-78	78-79	79-8
1) Hurricanes	272	9	2	-	-	3	32	2	-	-	2
2) Tornadoes	78	145	22	31	412	48	40	11	21	100	2
3) Wind Storms	3	2	14	1	8	7	44	54	164	6	2
4) Floods Flash Floods	51	22	519	105	71	48	55	165	196	143	7
5) Fire	165	161	128	143	278	159	166	416	231	270	21
6) Explosions	124	68	95	52	4	15	31	18	36	11	
7) Transportation		64	29	112	33	283	38	168	63	157	5
8) Other[1]		73	12	37	7	15	9	11	4	62	9
Totals	693	544	821	481	813	578	415	845	715	749	51

[1]This category includes earthquakes.

Table 2-3 Summary: American Red Cross Data - Injuries by Type of Disaster, 1970-80

	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77	77-78	78-79	79-8
1) Hurricanes	9,062	4,498	235	-	-	8	4,409	23	8	-	6,7
2) Tornadoes	2,521	1,823	653	993	10,574	688	1,213	369	448	4,209	1,0
3) Wind Storms	22	71	1,165	72	106	366	387	187	5,096	127	2,9
4) Floods Flash Floods	783	58	16,587	1,559	366	500	2,071	1,469	3,712	3,842	1,1
5) Fire	461	452	364	374	890	515	722	1,092	1,135	876	6
6) Explosions		90	432	102	136	421	123	97	127	52	1
7) Transportation	240	62	48	123	3	27	95	101	382	130	
8) Other		1,070	104	64	77	18	51	28	82	128	8
Totals	13,098	8,124	19,588	3,287	12,152	2,513	9,071	3,366	10,990	9,364	13,6

Table 2-4. Summary: American Red Cross Data - Dwellings (All Types) Destroyed by Type of Disaster, 1970-80

	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77	77-78	78-79	79-80
1) Hurricanes	6,046	1,887	36	-	-	45	4,642	15	6	1	7,097
2) Tornadoes	841	1,191	332	1,135	10,283	1,367	1,609	589	1,153	5,112	1,436
3) Wind Storms	21	117	424	104	113	238	610	106	476	144	668
4) Floods Flash Floods	83	105	7,346	3,229	1,417	803	1,377	3,581	1,489	2,659	887
5) Fire	128	1,018	183	602	556	3,391	3,431	4,194	4,869	5,121	5,252
6) Explosions		-	27	56	2	143	100	72	34	16	45
7) Transportation	64	-	5	2	7	-	2	11	13	12	-
8) Other		92	-	27	3	6	45	-	25	50	177
Totals	7,183	4,410	8,353	5,155	12,381	5,993	11,816	8,568	8,065	13,115	15,324

3. FEMA OUTLAY STATISTICS

FEMA outlays for disasters for fiscal years 1970-1980 are summarized in Table 3-1. FEMA outlays for the National Insurance Development Fund and the National Flood Insurance Fund for the same fiscal years are summarized in Table 3-2. They are provided in a separate chart in that outlays for these two insurance funds are not necessarily related to Presidentially-declared disasters or emergencies.

Computations taking into consideration variations in the CPI and 1980 dollars have been done by J.H. Wiggins. He has computed the maximum probable loss year as $4.5 billion. Some of the basis for this computation has been included in the last half of Table 3-1. Dr. Wiggins has also provided this note:

> It is important to recognize that a 10-year data summary is highly inadequate from the standpoint of estimating any maximum probable outlay by the federal government. Using the data alone and log normal distribution, I obtained $4.5 billion as the maximum probable loss year (PML defined as a 475-year series of events, an extreme value distribution would reveal even a higher number). It should also be recognized that FEMA does not pay for all the losses; neither does the insurance industry pick up the remainder. I would estimate that, even today, between 50% and 75% of all losses are still borne by the impacted persons. Thus,

> if the mean average annual outlay by FEMA is $500 million (1980 dollars) and if the insurance industry suffers a similar amount, approximately $4 billion is lost annually. Note this is a very crude approximation and includes first losses only.[1]

He also notes that FEMA's outlay for 475-year one-year period event could be on the order of between $15 billion and $30 billion.[2]

[1]Personal Communication, J.H. Wiggins, February 11, 1982
[2]Ibid.

Table 3-1. FEMA Outlays for Disasters, Fiscal Years 1970-1980 (October 1 to September 30 fiscal years)

OBLIGATIONS[1]	FISCAL YEAR										
	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
Major Disasters	$71,148,147	251,496,629	1,571,412,544	202,474,028	125,238,298	176,193,391	210,773,831	376,733,927	247,282,661	621,414,142	264,953,415
Emergency Declarations[2]					830,633	229,087	80,686,717	27,585,431	62,916,350	29,359,781	237,853,628
Fire Suppression[3]	1,057,509	767,872	-0-	486,628	734,251	34,229	1,269,719	4,721,455	202,993	767,166	27,926
CPIX	2.5	2.35	2.20	2.05	1.90	1.75	1.60	1.45	1.30	1.15	
1980$	180	592	3,456	414	241	308	469	595	403	748	503
	2,255	2,772	3,538	2,617	2,382	2,489	2,671	2,775	2,605	2,874	2,702

[1]This includes outlays for the following types of disasters: wind storm, tornado, hurricane, typhoon, heavy rain, snow, freezing, blizzard, severe storm, flooding, mudslide, high tides, levee break, dam failure, drought, water shortage, fire, volcanic eruption, earthquake, power failure, toxic algae, chemical waste, and undocumented aliens.

Staff working in State and Local estimate that as much of 90% of these outlays are flood related. Present computer programing does not permit the separation out of information by type of disaster, although such information is, of course, included. It also should be noted that many disasters and declared emergencies are more than one type of disaster or emergency, e.g., severe storms and flooding, tornadoes, heavy rains, and flooding.

[2]"Emergency declaration" is a designation which has been used since 1973. The term is used to refer to those occurrences of a potentially disastrous character which have not emerged as full blown disasters as yet, but may.

[3]Outlays for fire suppression are not included in other totals.

Table 3-2. FEMA Outlays for the National Insurance Development Fund and the National Flood Insurance Fund, FY 1970-1980

NET OUTLAYS[1] (in thousands)	FISCAL YEAR										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
National Insurance Development Fund	-28,491	-13,418	-1,767	-6,347	-4,269	-2,350	-1,649	3,044	9,403	11,954	23,586
National Flood Insurance Fund	1,010	3,140	6,808	14,454	51,463	44,208	117,497	96,635	107,758	238,623	382,214

[1] Increase in outlays is more representative of growth in the program than any increase in property loss. Figures represent net outlays in which damages, costs of administering the insurance mechanism, and interest on treasury borrowings are offset by premium income.

4. THE WIGGINS REPORT

Expected annual losses from natural disaster exposure relating to buildings and their occupancy for 1970 and for the year 2000 are summarized here in Tables 4-1 through 4-4.

The source of the tables, a 1978 study by the J.H. Wiggins Company, analyzed various impacts and public policy approaches to reducing loss from natural disasters. It is important to note that these figures are all developed on a consistent base using constant 1970 replacement dollars. The large increase in tornadoes, hurricanes, and storm surge losses are based on substantial encroachment by residential development into risk areas. The relatively modest riverine increase is based on effective flood plain regulation. The loss figures relate to building costs only and do not reflect damage to transportation or other infrastructure elements. Generally, the total cost of destruction is estimated to be between two and two and one-half times building losses.[1]

[1]This paragraph is drawn from FEMA Briefing Notes, Budget Justification, FY 1982.

Table 4-1. Summary: Selected Annual Losses for Natural Hazard Exposures in the United States by Type of Hazard and Type of Loss, 1970

HAZARD	Losses Relating to Property and Income (in millions - constant 1970 $)	Number of Deaths
1. Earthquake	781.1	273
2. Expansive Soil	798.1[1]	-
3. Hurricane	1056.0	62
4. Landslides	370.3	-
5. Riverine Flooding	2758.3	190
6. Severe Wind	18.0	5
7. Storm Surge	641.2	37
8. Tornado	1656.0	392
9. Tsunami	15.0	20
TOTALS	8094.0	979

[1] Residences only. Increase by 25% to include industrial/commercial.

Table 4-2. Summary: Selected Expected Annual Losses for Natural Hazard Exposures in the United States, by Type of Hazard and Type of Loss, 2000

HAZARD	Losses Relating to Property and Income (in millions - constant 1970 $)	Number of Deaths
1. Earthquake	1553.7	400
2. Expansive Soil	997.1[1]	-
3. Hurricane	3526.3	153
4. Landslides	871.2	-
5. Riverine Flooding	3175.33	159
6. Severe Wind	53.4	11
7. Storm Surge	2342.9	103
8. Tornado	5219.1	920
9. Tsunami	40.4	44
TOTALS	17,779.43	1790

(Based on tables from Petak et al., 1978, p. 4-3)

[1] Residences only. Increase by 25% to include industrial/commercial.

Table 4-3. Annual Losses from Natural Hazard Exposures in the United States by Type of Hazard and Type of Loss, 1970[1]

HAZARD	ANNUAL LOSSES: DOLLAR LOSSES RESULTING FROM INDICATED FACTOR (MILLIONS OF DOLLARS)					OTHER LOSSES			
	(1) BUILDING DAMAGE	(2) CONTENTS DAMAGE	(3) INCOME (a) LOSS	(4) SUPPLIER (b) LOSS	(5) TOTAL (1-4)	(6) NUMBER OF DEATHS	(7) HOUSING UNITS LOST	(8) PERSON YEARS OF HOMELESSNESS	(9) PERSON YEARS OF UNEMPLOY.
1. EARTHQUAKE	655.2	123.23	2.651	0.030	781.1	273	20,485	736	413.5
2. EXPANSIVE SOIL[2]	798.1	-	-	-	798.1	-	-	-	-
3. HURRICANE	685.5	267.57	101.803	1.092	1056.0	62	31,885	34,506	21,003.7
4. LANDSLIDES	370.3	-	-	-	370.3	-	-	-	-
5. RIVERINE FLOODING	1901.0	847.02	10.166	0.120	2758.3	190	-	-	-
6. SEVERE WIND	11.4	4.47	2.090	0.022	18.0	5	547	852	373.1
7. STORM SURGE	441.6	197.24	2.367	0.028	641.2	37	24,521	7,290	369.7
8. TORNADO	879.8	469.93	302.821	3.451	1656.0	392	36,212	86,122	57,541.6
9. TSUNAMI	8.7	5.54	0.727	0.012	15.0	20	234	345	97.5
TOTALS	5751.6	1915.0	422.625	4.755	8094.0	979	113,884	129,850	79,799.1

(a) Total loss of worker earnings associated with hazard caused unemployment.
(b) Total loss of income experienced by suppliers of businesses and industries experiencing hazard-induced shutdowns.

(Petak et al., 1978, p. 4-3)

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1 All dollar losses in 1970 dollars.
2 Residences only. Increase by 25% to include industrial/commercial.

Table 4-4. Expected Annual Losses from Natural Hazard Exposures in the United States by Type of Hazard and Type of Loss, 2000[1]

HAZARD	ANNUAL LOSSES								
	DOLLAR LOSSES RESULTING FROM INDICATED FACTOR (MILLIONS OF DOLLARS)					OTHER LOSSES			
	(1) BUILDING DAMAGE	(2) CONTENTS DAMAGE	(3) INCOME (a) LOSS	(4) SUPPLIER (b) LOSS	(5) TOTAL (1-4)	(6) NUMBER OF DEATHS	(7) HOUSING UNITS LOST	(8) PERSON YEARS OF HOMELESSNESS	(9) PERSON YEARS OF UNEMPLOY.
1. EARTHQUAKE	1177.0	372.78	3.906	0.048	1553.7	400	22,888	648	634.9
2. EXPANSIVE SOIL[2]	997.1	-	-	-	997.1	-	-	-	-
3. HURRICANE	1742.0	1504.98	276.191	3.095	3526.3	153	52,237	48,271	58,223.7
4. LANDSLIDES	871.2	-	-	-	871.2	-	-	-	-
5. RIVERINE FLOODING	1594.0	1572.54	8.68	.105	3175.33	159	-	-	-
6. SEVERE WIND	24.8	23.8	4.696	0.051	53.4	11	748	1,014	850.9
7. STORM SURGE	1176.0	1160.43	6.407	0.077	2342.9	103	43,757	10,330	1,018.3
8. TORNADO	2058.0	2401.32	750.780	9.042	5219.1	920	52,119	107,650	146,568.5
9. TSUNAMI	19.8	19.10	1.479	0.027	40.4	44	335	389	195.9
TOTALS	9659.9	7054.95	1052.139	12.445	17,779.43	1790	172,084	168,302	207,492.2

(a) Total loss of worker earnings associated with hazard caused unemployment.
(b) Total loss of income experienced by suppliers of businesses and industries experiencing hazard-induced shutdowns.

(Petak et al., 1978, p. 4-3)

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1 All dollar losses in 1970 dollars.
2 Residences only. Increase by 25% to include industrial/commercial.

5. D. EARL JONES ESTIMATES

The tables of statistics which follow in this section are based on a compilation done by D. Earl Jones ten years ago, included in a presentation made in 1981. (See Appendix J.) In order to get current dollar values, the dollar values in the compilation done in 1970 have been multiplied by a factor of two. The compiler views the resulting figures as "essentially ballpark figures."

Of note is Jones' view that only 22% of natural disasters are apt to "show up as...Presidentially declared disaster(s)." (Jones, 1981)

A summary is provided of Jones' "coarsely estimated average annual natural hazards losses." This is followed by a more detailed table of the same data and a table in which hazards are rank-ordered by estimated magnitude of average annual losses.

Jones notes that these statistical compilations are based in part on his subjective judgments and in part on documentation. (Jones, 1981)

Table 5-1. Summary: Coarsely Estimated Average Annual Natural Hazard Losses

HAZARD	CURRENT AVERAGE ANNUAL LOSS (in millions of dollars)
Wind	3,880
Earth and Soil Movements	15,540
Water	7,342
Tectonic	520
Landsliding	1,002
Corrosion	1,800
Vulcanism	10
Fire	4,560
Climatic	6,622
Life Forms	24,068
Erosion	1,400
Radiation (Natural)	20
Total average annual natural hazards losses =	$66,764

(Tables 5-1, 5-2, and 5-3 are all adapted from Jones, 1981.)

Table 5-2. Coarsely Estimated Average Annual Natural Hazard Losses

HAZARD	CURRENT AVERAGE ANNUAL LOSS (in million of dollars)	
Wind		
Hurricane	$ 400	
Tornado	2,000	
Windstorms	1,200	
Other	220	
		3,880
Earth and Soil Movements		
Shrink-Swell Phenomena	9,000	
Shallow Consolidation	4,000	
Other	2,540	
		15,540
Water		
River Bank Overflow	2,000	
Hurricane Surge	1,400	
Conduit Backwater Flooding	1,600	
Other	2,342	
		7,342
Tectonic		
Seismic Shaking	480	
Fault Ruptures	20	
Liquefaction	20	
		520
Landsliding		
Rotational Landslides	500	
Block Landslides	80	
Other	422	
		1,002
Corrosion		
All Natural Forms	1,800	
		1,800
Vulcanism		
Lava Flow	2	
Ashfall	6	
Gaseous Flows	2	
		10
Fire		
Forest Fire	4,000	
Brush and Grass Fires	400	
Ground Fire	160	
		4,560

Table 5-2. (Cont'd) Coarsely Estimated Average Annual Natural Hazard Losses

HAZARD	CURRENT AVERAGE ANNUAL LOSS (in million of dollars)	
Climatic		
Snowfall	3,000	
Frost	800	
Hail	800	
Drought	800	
Other	1,222	
		6,622
Life Forms		
Animal (4 legged)	8,000	
Insect	16,000	
Other	68	
		24,068
Erosion		
Wind Erosion	400	
Water Erosion	700	
Sedimentation	300	
		1,400
Radiation		
Natural Radiation	20	
		20
Total average annual natural hazard losses =		66,764

(Adapted from Jones, 1981)

Table 5-3. Hazards Rank-Ordered by Estimated Magnitude of Average Annual Losses (in millions of dollars)

HAZARD	(AAD) AVERAGE ANNUAL LOSS (Est.)	(PHAD) PROBABLE MAX. ANNUAL DAMAGE	PHAD	RANK ORDERED AAD
Insects	$16,000	20,000	3	1
Shrink-Swell Phenomena	9,000	10,000	4	2
Animal (4-legged)	8,000	10,000	5	3
Shallow Consolidation	4,000	4,000	10	4
Forest Fire	4,000	4,400	9	5
Snowfall	3,000	5,000	8	6
Tornado	2,000	3,000	12	7
River Bank Overflow	2,000	2,800	15	8
Natural Corrosion	1,800	1,800 (probably low)	18	9
Alkali Heave	1,800	2,000	16	10
Conduit Backwater Flooding	1,600	1,700	19	11
Hurricane Surge	1,400	2,000	17	12
Windstorms	1,200	1,600	20	13
Frost	800	2,000	13	14
Drought	800	4,000	11	15
Groundwater Flooding	800	900	22	16
Hail	800	900	23	17
Water Erosion	700	900	24	18
Frost Heave	600	800	25	19
Headwater Flooding	500	600	29	20
Lightning	500	600	30	21
Rotational Landslides	500	700	28	22
Seismic Shaking	480	280,000+(incl. fire)	1	23
Hurricane Winds	400	800	27	24
Deep Consolidation	400	400	34	25
Flash Floods	400	500	31	26
Other Landslides	400	500	32	27
Brush and Grass Fires	400	500	33	28
Wind Erosion	400	6,000	7	29
Mud Flows	300	400	35	30
Sedimentation	300	360	36	31
Local Winds (Foehns)	160	200	38	32
Ground Fire	160	200	39	33
Flooding Due to Subsidence	140	140	45	34
Wave Impacts	120	160	42	35
Subsidence Over Mines	120	300	37	36

Table 5-3. (Contd.) Hazards Rank-Ordered by Estimated Magnitude of Average Annual Losses (in millions of dollars)

HAZARD	(AAD) AVERAGE ANNUAL LOSS (Est.)	(PHAD) PROBABLE MAX. ANNUAL DAMAGE	PHAD	RANK ORDERED AAD
Tsunami and Seiche	100	1000	21	37
Snow Avalanche	100	140	44	38
Soil Creep	80	80	47	39
Block Landslides	80	160	43	40
Sinkholes	60	180	41	41
Soil Collapse	60	80	48	42
Ice Jam Backup	40	60	51	43
Debris Jam Backup	40	60	52	44
Fish and Aquatic Life	40	40	53	45
Bird Life	24	100	46	46
Natural Radiation	20	20	55	47
"Quick" Conditions	20	40	54	48
Dam Breakage Flooding	20	10,000	6	49
Fault Ruptures	20	3,000	14	50
Liquefaction	20	30,000	2	51
Lateral Spreading Landslides	20	200	40	52
Ice Fall	20	20	56	53
Ashfall	6	80	49	54
Reptile Life	4	4	58	55
Geologic Sink Flooding	2	2	59	56
Lava Flow	2	80	50	57
Gaseous Flows	2	800	26	58
Marsh Gas	2	2	60	59
Rockfall	2	10	57	60
	$66,764			

(adapted from Jones, 1981)

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APPENDICES

Table 7-1. CATASTROPHIC ACCIDENTS* AND DEATHS, BY TYPE OF ACCIDENT[1]
United States, 1941-75

Type of Accident	1941-45 Acci-dents	1941-45 Deaths	1946-50 Acci-dents	1946-50 Deaths	1951-55 Acci-dents	1951-55 Deaths	1956-60 Acci-dents	1956-60 Deaths	1961-65 Acci-dents	1961-65 Deaths	1966-70 Acci-dents	1966-70 Deaths	1971-75 Acci-dents	1971-75 Deaths	1941-75 Acci-dents	1941-75 Deaths
All Types**	482	6,839	568	6,412	678	6,769	805	7,021	724	6,602	616	5,911	520	5,610	4,393	45,164
Motor vehicle	128	916	164	1,069	289	1,732	377	2,305	324	2,045	237	1,508	140	941	1,659	10,516
Bus	36	347	23	192	17	136	15	128	16	183	15	130	13	126	135	1,242
Collision with railroad train	9	97	3	42	3	22	2	13	3	63	2	27	3	19	25	283
Other	27	250	20	150	14	114	13	115	13	120	13	103	10	107	110	959
Motor vehicle other than bus	92	569	141	877	272	1,596	362	2,177	308	1,862	222	1,378	127	815	1,524	9,274
Collision with railroad train	34	216	35	215	51	295	43	279	36	223	19	123	10	58	228	1,409
Other	58	353	106	662	221	1,301	319	1,898	272	1,639	203	1,255	117	757	1,296	7,865
Air transportation	27	380	61	991	59	1,043	53	1,090	75	1,327	101	1,541	95	1,384	471	7,756
Water transportation	45	632	44	380	46	421	36	298	26	212	19	204	9	117	225	2,264
Railroad***	28	548	17	313	12	193	12	176	3	30	3	22	3	60	78	1,342
Fire and explosion	146	2,391	184	2,138	190	1,354	230	1,745	221	1,630	199	1,460	199	1,419	1,369	12,137
Dwellings, apartments	53	326	113	708	135	822	177	1,095	177	1,061	145	908	135	796	935	5,716
Hotels, boarding houses, rooming houses	18	213	18	302	15	119	9	56	8	79	17	164	16	139	101	1,072
Homes for aged, convalescent homes, hospitals, etc.	8	99	8	182	10	129	7	125	9	156	3	44	14	126	59	861
Places of amusement	5	679	-	-	-	-	2	26	2	94	1	5	2	31	12	835
Other	62	1,074	45	946	30	284	35	443	25	240	33	339	32	327	262	3,653
Tornadoes, floods, hurricanes, etc.	50	1,163	61	1,129	48	1,649	50	1,033	41	1,062	39	948	46	1,295	335	8,279

Table 7-1. (Contd.) CATASTROPHIC ACCIDENTS* AND DEATHS, BY TYPE OF ACCIDENT[1]
United States, 1941-75

Type of Accident	1941-45		1946-50		1951-55		1956-60		1961-65		1966-70		1971-75		1941-75	
	Accidents	Deaths	Accidents	Deaths	Accidents	Deaths	Accidents	Deaths	Accidents	Deaths	Accidents	Deaths	Accidents	Deaths	Accidents	Deaths
Mines and quarries..........	37	607	16	263	12	207	10	132	9	140	6	158	4	111	94	1,618
All other....................	21	202	21	129	22	170	37	242	25	156	12	70	24	283	162	1,252

*Accidents in which five or more persons were killed.

**Excludes military aviation accidents.

***Collisions of railroad trains with motor vehicles are classified as motor vehicle accidents.

Source of basic data: News items in the daily press, reports of the National Weather Service, U.S. Bureau of Mines, and other sources. Data may be incomplete, particularly with regard to accidents taking five to nine lives.

[1]Metropolitan Life Insurance Company Statistical Bulletin, March 1977.

TABLE 7-2. MAJOR CATASTROPHES IN THE UNITED STATES - 1974-1980
Accidents Taking 25 or More Lives

Date	Place	Type of Accident	Number of Lives Lost
	1980		
November 21...	Las Vegas, Nev..................	Fire in hotel.........................	84
May 18........	Mount St. Helens, Wash.........	Volcanic eruption.....................	61
May 9.........	Tampa Bay, Fla.................	Collision of ship with bridge during rainstorm.....................	35
February 13-21	Southern California............	Rain, floods, and subsequent mud slides..........................	30
	1979		
May 25........	O'Hare Airport, Chicago, Ill...	Crash of Scheduled Plane.............	273
April 10......	Wichita Falls, Texas...........	Tornado..............................	42
November 1....	Gulf of Mexico Off Galveston, Texas...........	Collision of tanker and freighter....	32
April 2.......	Farmington, Mo.................	Fire in retirement home..............	25
	1978		
September 25...	San Diego, Calif...............	Collision of scheduled and private planes..............................	144
January 25-27..	Midwest........................	Blizzard.............................	80
April 27.......	Willow Island, W. Va...........	Collapse of scaffolding inside cooling tower of power plant under construction	51
February 5-7...	Northeast	Severe snowstorm.....................	50
August 2-3.....	Texas..........................	Floods...............................	27
	1977		
May 28.........	Southgate, Ky..................	Fire in night club...................	165
July 20........	Johnstown, Pa..................	Floods...............................	80
April 4........	New Hope, Ga...................	Crash of scheduled plane.............	71
January 27-February 1...	Buffalo, N.Y., and Illinois, Indiana, Michigan, Ohio........	Blizzard.............................	51
November 6...	Toccoa, Ga.....................	Collapse of earthen dam..............	39
December 22....	Westwego, La...................	Explosion of grain elevator..........	36
December 13....	Evansville, Ind................	Crash of chartered plane.............	29
September 12-13	Kansas City, Mo................	Flash floods.........................	26
	1976		
July 31........	Big Thompson River Canyon, Colo..................	Flash flood..........................	145
October 20......	Mississippi River.............	Collision of ferry and tanker........	77
May 21..........	Martinez, Calif...............	Crash of school bus..................	29
March 9-11......	Near Whitesburg, Ky...........	Explosions in coal mine..............	26

TABLE 7-2. (Contd.) MAJOR CATASTROPHES IN THE UNITED STATES - 1974-1980
Accidents Taking 25 or More Lives

Date	Place	Type of Accident	Number of Lives Lost
	1975		
June 24.........	New York, N.Y.................	Crash of scheduled plane.............	113
January 10-12...	Upper Midwest.................	Blizzard............................	34
November 10.....	Lake Superior, Mich...........	Sinking of ore carrier during a storm	29
January 31......	Delaware River, Pa............	Collision of two tankers.............	26
	1974		
April 3-4.......	Midwest and South.............	Series of tornadoes..................	307
December 1......	Near Upperville, Va...........	Crash of scheduled plane.............	92
September 11....	Near Charlotte, N.C...........	Crash of scheduled plane.............	72
March 13........	Near Bishop, Calif............	Crash of chartered plane in mountains............................	36
June 8..........	Oklahoma, Kansas, and Arkansas......................	Tornadoes and flash floods...........	26

NOTE: Figures for natural disasters are approximate.

[1]1976-1980 data are from Metropolitan Life Insurance Company Statistical Bulletin, January-March 1981; 1974 and 1975 data are from the January-March 1979 issue.

APPENDIX C - American Red Cross Data - Fiscal Years 1970-1980

Table 7-3. **FY 1979-1980 American Red Cross Data**

SELECTED DATA FOR 3,418 DISASTER RELIEF OPERATIONS
(THESE OPERATIONS WERE TOTALLY OR PARTIALLY FINANCED BY NATIONAL.)

	HURRICANES	TORNADOES	WINDSTORMS & OTHER STORMS	FLOODS & FLASH FLOODS	FIRES	EXPLO-SIONS	TRANS-PORTATION MISHAPS	OTHER	TOTAL
Number of Operations	6	59	56	122	3,092	21	24	38	3,418
Chapters Involved	109	94	90	218	585	19	25	60	888 (Net)
States, Dist. of Columbia & Territories Affected	12	26	29	37	49	15	12	23	55 (Net)
Persons:									
Killed	20	26	22	79	218	5	53	92	515
With Injuries Or Illnesses	6,765	1,042	2,995	1,121	696	107	77	812	13,615
Given Emergency Care	308,547	59,438	49,835	97,115	18,731	1,322	8,904	144,809	688,701
Families Assisted	54,598	3,838	8,407	15,677	6,947	99	16	893	90,475
Single Family Houses									
Destroyed	2,525	879	567	366	1,335	27	-	95	5,794
Damaged	60,091	5,115	12,833	32,107	690	415	-	103	111,354
Mobile Homes									
Destroyed	4,316	432	87	423	450	3	-	67	5,778
Damaged	2,625	445	1,216	1,660	42	13	-	291	6,292
Apts. & Condominiums									
Destroyed	56	125	14	98	3,467	15	-	15	3,790
Damaged	2,317	674	2,236	3,672	3,342	139	-	944	13,324

NOTE: The statistical tables in this section are from the Annual Summaries of Disaster Services Activities of the American Red Cross for the years 1969-1980.

Table 7-4. FY 1978-1979 American Red Cross Data

SELECTED DATA FOR 2,446 DISASTER RELIEF OPERATIONS
(IN GENERAL, THESE OPERATIONS REQUIRED NATIONAL EXPENDITURES)

	HURRICANES	TORNADOES	WINDSTORMS & OTHER STORMS	FLOODS & FLASH FLOODS	FIRES	EXPLOSIONS	TRANSPORTATION MISHAPS	OTHER	TOTAL
Number of Operations	1	44	80	148	2,097	13	26	37	2,446
Chapters Involved	1	106	97	433	487	13	23	30	950 (Net)
States, Dist. of Columbia & Territories Affected	1	20	41	53	51	10	13	18	52 (Net)
Persons:									
Killed	-	100	6	143	270	11	157	62	749
With Injuries Or Illnesses	-	4,209	127	3,842	876	52	130	128	9,364
Given Emergency Care	38	130,465	29,090	284,778	29,684	2,804	6,204	11,082	494,145
Families Suffering Loss	12	15,017	2,628	60,244	13,815	105	321	895	93,037
Families Assisted	3	6,694	1,476	25,990	8,688	39	17	281	43,188
Dwellings									
Destroyed	1	3,224	84	1,341	947	2	6	22	5,627
Damaged	3	8,128	1,704	50,804	476	34	27	25	61,201
Mobile Homes									
Destroyed	-	468	58	1,178	388	8	-	1	2,101
Damaged	-	731	73	3,004	24	18	-	350	4,200
Apts. & Condominiums									
Destroyed	-	1,420	2	140	3,786	6	6	27	5,387
Damaged	-	858	115	2,838	6,498	25	-	118	10,452

Table 7-5. FY 1977-1978 American Red Cross Data

SELECTED DATA FOR 1,341 DISASTER RELIEF OPERATIONS
(IN GENERAL, THESE OPERATIONS REQUIRED NATIONAL EXPENDITURES)

	HURRICANES	TORNADOES	WINDSTORMS & OTHER STORMS	FLOODS & FLASH FLOODS	FIRES	EXPLO-SIONS	TRANS-PORTATION MISHAPS	OTHER	TOTAL
Number of Operations	3	49	78	106	1,031	15	32	27	1,341
Chapters Involved	25	96	276	205	293	12	27	19	746 (Net)
States, Dist. of Columbia & Territories Affected	3	23	35	41	50	10	14	12	49 (Net)
Persons:									
Killed	-	21	164	196	231	36	63	4	715
With Injuries or Illnesses	8	448	5,096	3,712	1,135	127	382	82	10,990
Given Emergency Care	30,910	23,165	298,619	210,719	29,549	2,685	8,683	21,980	626,310
Families Suffering Loss	750	7,933	23,999	51,505	12,824	375	421	1,233	99,040
Families Assisted	202	1,449	11,311	26,247	7,908	104	25	500	47,746
Dwellings									
Destroyed	5	307	382	868	515	3	9	-	2,089
Damaged	626	5,697	15,809	43,260	215	75	4	85	65,771
Mobile Homes									
Destroyed	1	427	92	466	78	-	-	-	1,064
Damaged	36	287	704	1,359	11	-	-	-	2,397
Apts. & Condominiums									
Destroyed	-	419	2	155	4,276	31	4	25	4,912
Damaged	80	326	592	3,889	6,924	164	-	129	12,104

Table 7-6. FY 1976-1977 American Red Cross Data

SELECTED DATA FOR 963 DISASTER RELIEF OPERATIONS
(IN GENERAL, THESE OPERATIONS REQUIRED NATIONAL EXPENDITURES)

	HURRICANES	TORNADOES	WINDSTORMS & OTHER STORMS	FLOODS & FLASH FLOODS	FIRES	EXPLO-SIONS	TRANS-PORTATION MISHAPS	OTHER	TOTAL
Number of Operations	1	37	24	58	800	12	17	14	963
Chapters Involved	23	70	115	170	413	12	17	12	496(Net)
States, Dist. of Columbia & Territories Affected	6	24	26	30	43	12	10	9	49(Net)
Persons:									
Killed	2	11	54	165	416	18	168	11	845
With Injuries or Illnesses	23	369	187	1,469	1,092	97	101	28	3,366
Given Emergency Care	51,148	17,960	120,131	80,380	42,013	1,417	2,977	5,702	321,728
Families Suffering Loss	527	3,577	5,844	45,690	12,075	235	217	126	68,291
Families Assisted	29	725	4,370	23,869	6,718	80	15	71	35,877
Dwellings									
Destroyed	15	369	42	2,384	331	21	11	-	3,173
Damaged	427	2,556	2,397	32,912	161	82	6	28	38,569
Mobile Homes									
Destroyed	-	192	59	1,194	25	1	-	-	1,471
Damaged	1	274	96	1,881	22	4	-	-	2,278
Apts. & Condominiums									
Destroyed	-	28	5	3	3,838	50	-	-	3,924
Damaged	70	112	169	1,149	6,947	56	-	36	8,539

Table 7-7. FY 1975-1976 American Red Cross Data

SELECTED DATA FOR 1,005 DISASTER RELIEF OPERATIONS
(IN GENERAL, THESE OPERATIONS REQUIRED NATIONAL EXPENDITURES)

	HURRICANES	TORNADOES	WINDSTORMS & OTHER STORMS	FLOODS & FLASH FLOODS	FIRES	EXPLOSIONS	TRANSPORTATION MISHAPS	OTHER	TOTAL
NUMBER OF OPERATIONS	3	74	39	70	774	11	10	24	1,005
CHAPTERS INVOLVED	103	168	88	125	322	11	11	20	546(NET)
STATES, DIST. OF COLUMBIA & TERRITORIES AFFECTED	17	66	33	69	306	10	11	18	53(NET)
PERSONS:									
KILLED	32	40	44	55	166	31	38	9	415
WITH INJURIES OR ILLNESSES	4,409	1,213	387	2,071	722	123	95	51	9,071
GIVEN EMERGENCY CARE	102,381	24,315	57,979	95,027	29,967	1,849	2,698	7,194	321,410
FAMILIES SUFFERING LOSS	48,970	8,240	180,806	34,968	10,933	402	589	1,266	286,174
FAMILIES GIVEN INDIVIDUAL ASSISTANCE	27,524	2,326	19,363	9,836	5,140	230	24	211	64,654
DWELLINGS									
DESTROYED	3,516	792	445	921	210	6	2	22	5,914
DAMAGED	27,497	5,699	27,808	21,300	680	54	121	371	83,530
MOBILE HOMES									
DESTROYED	629	679	165	361	15	-	-	2	1,851
DAMAGED	994	513	183	1,576	19	-	-	558	3,843
APTS. & CONDOMINIUMS									
DESTROYED	497	138	-	95	3,206	94	-	21	4,051
DAMAGED	3,179	264	89	3,303	6,139	73	4	37	13,088

Table 7-8. FY 1974-1975 American Red Cross Data

SELECTED DATA FOR 1,023 DISASTERS INVOLVING
MORE THAN FIVE FAMILIES

	HURRICANES	TORNADOES	WINDSTORMS & OTHER STORMS	FLOODS & FLASH FLOODS	FIRES	EXPLOSIONS	TRANSPORTATION MISHAPS	OTHER	TOTAL
Number of Operations	2	54	37	90	801	12	7	20	1,023
Chapters Involved	52	102	83	151	341	9	7	18	483(NET)
States, Dist. of Columbia & Territories Affected	5	24	28	36	44	6	5	13	50(NET)
Persons:									
Killed	3	48	7	48	159	15	283	15	578
With Injuries or Illnesses	8	688	336	500	515	421	27	18	2,513
Given Emergency Care	101,603	38,488	59,510	47,776	19,126	5,350	1,791	4,500	278,144
Families Suffering Loss	2,675	9,265	8,151	26,700	9,740	2,655	131	642	59,959
Families Given Individual Assistance	1,553	3,562	1,096	9,745	6,125	148	37	72	22,338
Dwellings									
Destroyed	14	740	42	467	228	74	-	5	1,570
Damaged	1,817	6,521	6,748	21,953	382	1,917	-	522	39,860
Mobile Homes									
Destroyed	31	383	180	272	12	41	-	-	919
Damaged	697	449	176	939	-	100	-	2	2,363
Apts. & Condominiums									
Destroyed	-	244	16	64	3,151	28	-	1	3,504
Damaged	-	746	676	2,116	5,271	121	-	54	8,984

Table 7-9. FY 1973-1974 American Red Cross Data

SELECTED DATA FOR 963 DISASTERS INVOLVING
MORE THAN FIVE FAMILIES

	TORNADOES	WINDSTORMS & OTHER STORMS	FLOODS & FLASH FLOODS	FIRES	EXPLOSIONS	TRANSPORTATION MISHAPS	OTHER	TOTAL
NUMBER OF OPERATIONS	89	26	83	743	7	5	10	963
CHAPTERS INVOLVED	285	58	196	143	7	5	9	594(NET)
STATES & NON-DOMESTIC TERRITORIES AFFECTED (PUERTO RICO)	34	22	43	43	7	5	7	48(NET)
PERSONS:								
KILLED	412	8	71	278	4	33	7	813
WITH INJURIES OR ILLNESSES	10,574	106	366	890	136	3	77	12,152
GIVEN EMERGENCY CARE	189,817	39,929	69,629	18,584	2,859	1,801	7,852	330,471
FAMILIES SUFFERING LOSS	43,483	2,056	35,189	8,344	771	22	23	89,888
FAMILIES GIVEN INDIVIDUAL ASSISTANCE	14,076	500	13,970	5,672	24	9	12	34,263
DWELLINGS (INCL. MOBILE HOMES):								
DESTROYED	10,283	113	1,417	556	2	7	3	12,381
DAMAGED	26,478	1,589	31,309	1,193	80	4	25	60,678

Table 7-10. FY 1972-1973 American Red Cross Data

SELECTED DATA FOR 626 DISASTERS INVOLVING MORE THAN FIVE FAMILIES

	TORNADOES	WINDSTORMS & OTHER STORMS	FLOODS & FLASH FLOODS	FIRES	EXPLO-SIONS	TRANS-PORTATION MISHAPS	OTHER	TOTAL
Number of Operations	41	19	78	450	11	6	21	626
Chapters Involved	67	52	386	453	11	6	21	966 (Net)
States & Non-Domestic Territories Affected	17	17	49	35	7	6	12	45 (Net)
Persons:								
Killed	31	1	105	143	52	112	37	481
With Injuries or Illnesses	993	72	1,559	374	102	123	64	3,287
Given Emergency Care	18,822	35,308	148,575	13,463	4,488	1,905	5,396	227,957 [1]
Families Suffering Loss	5,934	5,030	99,245	6,059	1,057	229	547	118,101
Families Given Individual Assistance	961	929	24,344	3,560	110	59	175	30,138 [2]
Dwellings (Incl. Mobile Homes):								
Destroyed	1,135	104	3,229	602	56	2	27	5,155
Damaged	4,068	4,687	81,467	930	1,083	3	227	92,465

1 Does not include emergency care given to 504,042 persons on the relief operation for Tropical Storm Agnes, as these were included in the statistics for Fiscal Year 1971-72 Annual Summary of Disaster Services Activities.

2 Does not include 68,096 families given individual assistance following Tropical Storm Agnes.

Table 7-11. FY 1971-1972 American Red Cross Data

SELECTED DATA FOR 633 DISASTERS INVOLVING
MORE THAN FIVE FAMILIES

	HURRICANES	TORNADOES	WINDSTORMS & OTHER STORMS	FLOODS & FLASH FLOODS	FIRES	EXPLOSIONS	TRANSPORTATION MISHAPS	OTHER	TOTAL
Number of Operations	4	57	31	77	436	8	4	16	633
Chapters Involved	48	76	81	310	126	9	4	18	569(Net)
States, Dist. of Columbia & Insular Territories Affected	7	21	26	39	41	8	3	14	48(Net)
Persons:									
Killed	2	22	14	519	128	95	29	12	821
With Injuries or Illnesses	235	653	1,165	16,587	364	432	48	104	19,588
Given Mass Care	51,754	12,833	22,966	604,071	16,494	2,480	915	11,434	722,947
Families Suffering Loss	24,427	3,651	12,133	156,541	5,922	673	40	269	203,656
Families Given Individual Assistance	17,674	471	3,570	80,205	3,787	95	14	30	105,846
Dwellings (Incl. Mobile Homes):									
Destroyed	36	332	424	7,346	183	27	5	-	8,353
Damaged	24,258	2,429	9,287	133,803	162	258	4	2	170,203

Table 7-12. FY 1970-1971 American Red Cross Data

DISASTER RELIEF OPERATIONS
1970-71

	HURRICANES	TORNADOES	WINDSTORMS & OTHER STORMS	FLOODS & FLASH FLOODS	FIRES	EXPLOSIONS	TRANSPORTATION MISHAPS	OTHER*	TOTAL
NUMBER OF OPERATIONS	5	62	27	49	512	7	4	9	675
CHAPTERS INVOLVED	30	100	37	68	121	7	4	8	334 (NET)
STATES, DIST. OF COLUMBIA & INSULAR TERRITORIES AFFECTED	3	20	17	32	38	6	4	8	52 (NET)
PERSONS:									
KILLED	9	145	2	22	161	68	64	73	544
WITH INJURIES OR ILLNESSES	4,498	1,823	71	58	452	90	62	1,070	8,124
GIVEN MASS CARE	150,819	34,451	7,864	50,675	24,637	2,482	1,030	29,412	301,370
FAMILIES SUFFERING LOSS	43,696	8,543	9,431	25,018	9,118	342	3	95,177	191,328
FAMILIES GIVEN INDIVIDUAL ASSISTANCE	33,767	2,236	284	20,244	4,680	4	33	13,001	74,249
DWELLINGS (INCL. MOBILE HOMES):									
DESTROYED	1,887	1,191	117	105	1,018	-	-	92	4,410
DAMAGED	34,442	5,225	1,207	6,993	1,857	234	-	3,358	53,316

*INCLUDES STATISTICS FOR SOUTHERN CALIFORNIA EARTHQUAKE - FEB. 1971

Table 7-13. FY 1969-1970 American Red Cross Data

	HURRICANE	TORNADO	OTHER STORMS	FLOOD AND FLASH FLOOD	FIRE	EXPLOSIONS, TRANSP. MISHAPS & OTHER	TOTAL
KILLED	272	78	3	51	165	124	693
ILL & INJURED	9,062	2,521	22	783	461	240	13,089
DWELLINGS DESTROYED	6,046	841	21	83	128	64	7,183
REBUILT	273	49	4	13	6	-	345
(PCT. REBUILT)	(5)	(6)	(19)	(16)			(5)
DWELLINGS DAMAGED	48,734	6,113	3,950	33,769	239	294	93,099
REPAIRED	6,202	333	111	1,325	1	1	7,973
(PCT. REPAIRED)	(13)	(5)	(3)	(4)			(9)

Appendix D

Note: The form which follows was developed by the National Governors' Association to assure that governors receive key disaster information they need for management review purposes. FEMA comments have been incorporated so that information collected for the governor is compatible with data the governor must forward to FEMA when requesting federal assistance.

GOVERNORS' EMERGENCY REPORT (CY 19___, No. ___) State: ________ Fed. Reg.: ______

Jurisdiction(s) involved: ______________ Reporter: ______________ Date: ______

______________ Congressional Districts: ______________

______________ State Sen. Districts: ______________

Total area population: ______________ State Rep. Districts: ______________

Type of Incident: ______________

Start date: ________ Duration: ________ Date/time 1st public warning: ________

Local agencies on scene: ______________

State help requested: ☐ No ☐ Yes Type given: ______________

Lead agency tasked: ________ Date/time alerted: ________ Date/time on-site: ________

Private Sector: Deaths _____ Injuries _____ Hospitalized _____ Treated/released _____

Evacuated _____ Sheltered _____ Temp. hsg. _____ Other ______________

Total Area Damage Estimates ($000)	Homes	Apts., Multi-Family Res.	Mobile Homes	Bus. & ind. Bldgs.	Bus. & ind. Equip.	Agriculture Bldg./Eq.	Agriculture Crops	Agriculture Stock
Destroyed (=85%+)	#	#	#	#	#	#	#	#
	$	$	$	$	$	$	$	$
Damaged (=10-84%)	#	#	#	#	#	#	#	#
	$	$	$	$	$	$	$	$
Est. Cost Repairs	$	$	$	$	$	$	$	$
Insurance %								

Bus. closed: 1-7 days _____ 8-30 _____ 30+ _____ Unemployed: 1-7 days _____ 8-30 _____ 30+ _____

Public Facilities: Roads: ________ Bridges ________ Culverts ________

Water Control: Dams ________ Levees ________ Channels ________

Buildings: ________ Supplies/inventory ________ Vehicles/equip. ________

Utilities: Water $________ Sewer $________ Light/power $________ Other________

Effects: ______________

Recovery: Est. duration: ________ Special needs: ______________

COSTS ($000)	Private	Local	State	Federal	Total
Debris clearance	$	$	$	$	$
Life/health safety actions	$	$	$	$	$
Property safety actions	$	$	$	$	$
Road repair	$	$	$	$	$
Public prop. repair/replacement	$	$	$	$	$
Private prop. repair/replacement	$	$	$	$	$
Staff: overtime, new hires, expenses	$	$	$	$	$
Special services	$	$	$	$	$
	$	$	$	$	$

Special problems ______________

Recommendations ______________

Declaration Status: ☐ Local Issued ☐ State Issued ☐ Special Issued ________ ☐ Presidential Request E ___ MD ___ ☐ Presidential Issued E ___ MD ___

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Hypothetical example for illustrative purposes.

GOVERNORS' EMERGENCY REPORT (CY 19*81*, No. *61*) State: *Maryland* Fed. Reg.: *III*

Jurisdiction(s) involved: *Frederick, Baltimore and Upper Montgomery Counties/Apple Creek Valentine River*

Reporter: *S. Jones/DEM* Date: *7/15/81*

Congressional Districts: *47*

State Sen. Districts: *7, 21, 23*

Total area population: *230,000*

State Rep. Districts: *5, 11, 12, 19*

Type of Incident: *Severe storms, winds & flooding following tropical storm Alice*

Start date: *6/1/81* Duration: *2 days* Date/time 1st public warning: *5/31, 07:15*

Local agencies on scene: *Cy Sheriff, Fdk. Airport CAP, Boy Scouts, City EOC 6/1 02:30*

State help requested: ☐ No ☒ Yes Type given: *National Guard for S&R security, Decl.*

Lead agency tasked: *DEM* Date/time alerted: *5/30 23:07* Date/time on-site: *6/1 07:40*

Private Sector: Deaths *0* Injuries *123* Hospitalized *60* Treated/released *210*

Evacuated *1,455* Sheltered *450* Temp. hsg. *80* Other

Total Area Damage Estimates ($000)		Homes	Apts., Multi-Family Res.	Mobile Homes	Bus. & Ind. Bldgs.	Bus. & Ind. Equip.	Agriculture Bldg./Eq.	Agriculture Crops	Agriculture Stock
Destroyed (=85%+)	#	2	2	1	-	-	21	1,200	-
	$	90	45	25	-	-	246.6	1.4	-
Damaged (=10-84%)	#	4	4	4	251	-	-	-	-
	$	2.2	1.8	1.9	1,255.9	-	-	-	-
Est. Cost Repairs	$	92.2	46.8	26.9	1,255.9	-	246.6	1.4	-
Insurance %		80%	50%	100%	100%	-	23%	0%	-

Bus. closed: 1-7 days *696* 8-30 *155* 30+ *15* Unemployed: 1-7 days *12,560* 8-30 *1,550* 30+ *650*

Public Facilities: Roads: *34 mi. @ $65,200* Bridges *3 @ $156,000* Culverts *2 @ $5,900*

Water Control: Dams *0 @ $0* Levees *1 @ $152,000* Channels *1 @ $4,100*

Buildings: *4 @ $34,200* Supplies/inventory *0* Vehicles/equip. *2 @ $2,300*

Utilities: Water $*34,300* Sewer $ *5,200* Light/power $*3,500* Other *0*

Effects: *16 families isolated lower Berry Twp 2 days; parts Berry Twp no water/power 3 days; Carter Twp sewers ruptured; 4 detours delayed 15,000 commuters 2+ hrs Apple Creek*

Recovery: Est. duration: *60 da - 12/18 mo* Special needs: *welfare assistance*

COSTS ($000)	Private	Local	State	Federal	Total
Debris clearance	$ 180	$ 30	$ 5	$ 10	$ 225
Life/health safety actions	$ 65	$ 28	$ 12	$ 6	$ 111
Property safety actions	$ 17	$ 25	$ 14	$ 2	$ 58
Road repair	$ 75	$ 30	$ 8	$ 11	$ 124
Public prop. repair/replacement	$ 0	$ 310.7	$ 100	$ 52	$ 462.7
Private prop. repair/replacement	$ 1,615.8	$ 2	$ 2	$ 50	$ 1,669.8
Staff: overtime, new hires, expenses	$ 50	$ 18	$ 14	$ 5	$ 87
Special services	$ 10	$ 17	$ 3	$ 4	$ 34
	$ 2,012.8	$ 460.7	$ 158	$ 140	$ 2,771.5

Special problems *Sheriff released wrong damage info; Health dept/Cy Judge turf battle; insufficient flood insurance program Berry Twp/Cy*

Recommendations *Construct new levees, relocate @ 50 homes; raise/reinforce rte 694 through Berry Twp; promote Ag. & multi-family dwelling insurance*

Declaration Status: ☒ Local Issued ☒ State Issued ☒ Special Issued ☒ Presidential Request ☐ Presidential Issued

SBA, FmHA E *X* MD___ E ___ MD___

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Table 7-14. STATE EMERGENCY INCIDENTS TRENDS

	1973-78	JAN'78 - MAR'81
NATURAL EVENTS		
WIND, WATER, RURAL FIRES, SNOW AND ICE	1,082	2,811
DROUGHT AND RANGE INFESTATION	69	444
LAND MOVEMENT	19	152
TOTAL	1,170	3,407
MAN-MADE EVENTS		
URBAN FIRE	75	604
UTILITIES FAILURE, EXPLOSIONS, AIR CRASHES, OIL SPILLS	70	2,835
POLLUTION, EPIDEMICS	37	371
RADIATION	102	441
TERRORISM, CIVIL DISORDER	7	189
HAZARDOUS MATERIALS ACCIDENTS	—	5,724
FIXED FACILITIES	—	2,579
TRANSPORT RELATED	—	3,145
ENERGY SHORTAGES	—	81
TOTAL	291	10,245
TOTAL EMERGENCIES	1,461	13,652

THE FIGURES IN THE ABOVE TABLE INDICATE EVENTS THAT HAVE BEEN REPORTED TO STATE EMERGENCY SERVICES OFFICES. WE CANNOT BE SURE HOW WELL THEY REPRESENT THE ACTUAL NUMBER OF EMERGENCIES THAT HAVE OCCURRED THROUGHOUT THE UNITED STATES DURING THE TIME FRAME INDICATED. BUT THE FIGURES DO REFLECT A CHANGING TREND IN THE NUMBERS AND TYPES OF EMERGENCIES REPORTED.

March 15, 1978

Appendix F

THE ADEQUACY OF NATURAL DISASTER DATA BASES FOR

LOCATION AND DAMAGE ESTIMATES

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The Research Reported in this paper was conducted under NSF-RANN Grant "Research Program on Natural Recovery Processes"

I: Introduction:

The discussion of disaster data bases contained in the body of this paper is a distillation of the experiences we endured in an attempt to use existing disaster data bases to obtain the precise locations and resulting damages and injuries of disaster events —relating to floods, tornados, and hurricanes—occurring during the period 1960 to 1970. A bit of the background of our research endeavours may be helpful to the reader at this point: Our research was an attempt to estimate the long range (up to ten years) effects of disasters in that period on the housing and population stocks of small areas — Census tracts in SMSA's and counties. Our mode of procedure was to link together the 1960 and 1970 Census data for those areas, to model the growth (or decline) processes, arriving at predicted population and housing stocks for each area as a function of the state of each area's stock at the beginning of the period (1960), growth trends for tracts (or counties) of that sort, and growth trends for the metropolitan areas and regions in which the tract or county was located. By contrasting statistically those tracts or counties that had experienced floods, hurricanes or tornados in that period with statistically comparable tracts that had not experienced such events, we hoped to provide estimates of the kinds of effects on housing stocks and population compositions that would still be apparent at the end of the decade. Since the disasters in question are fairly frequent in occurrence, we would have some that occurred very early in the period and some that occurred quite late,

affording us the opportunity to make statements about the lengths of time necessary for the effects of a disaster of a given magnitude to be no longer apparent in differential growth or decline rates for such areas.

The data needs of this research effort were of the following sorts:

1. Precise Locations of Disasters:

   For our analysis of effects on counties, we needed to know which counties had experienced disasters of the relevant type. Since counties average about 95 square miles, the precision of the location data need not be very high.

   For the analysis of effects on Census tracts, we needed location data of considerable precision since tracts average about 8 square miles in area, varying considerably depending on the density of settlement within tracts.

2. Magnitudes of Disaster Damage and Injury:

   Since it would make little sense to study the long range effects of trivial events (e.g. tornados that struck a few trees in open country) we needed to have some measure of how serious were the resulting damages and injuries so that we could restrict our analysis to non-trivial events. In addition, we wanted to be able to allocate out damages to tracts within SMSA'a and to counties, as the analyses dictated.

3. Dates of Disaster Event Occurrences:

   Although initially we thought we needed considerable precision in this information — preferably accurate to within a month — it turned out that because there were so few disasters of sufficient magnitude to study, we could only distinguish between disasters that were a year or so apart, a purpose for which existing data bases were quite sufficient.

4. Housing and Population Counts for Comparable Small Areas Counties for 1960 and for 1970

   Since we intended to link together the 1960 and 1970 Censuses for Census tracts and counties, we needed to be able to assemble Census materials for areas that were comparable in boundaries for the two periods. We knew that some changes were made from Census to Census and hoped that such changes were minimal.

Some of our experiences with the various data bases are given in the next few sections of the paper.

II: Assembling Population and Housing Statistics for Areas Comparable in 1960 and 1970

Although we anticipated that there would be some difficulties linking together the two Censuses, we did not anticipate the extent to which areal boundaries for both tracts and counties changed from Census to Census. The decade 1960 to 1970 was one that was marked by a considerable growth in the American population and an even greater growth in its housing stock. Urbanization trends continued in that period with more and more of the population congregated within metropolitan areas. At the same time, within metro areas, growth and decentralization led to a large degree of reapportionment of residential locations within SMSA's. All these trends meant that the areal aggregates used by the U.S. Census and designed to reflect the political boundaries of localities, population distributions within such localities were changed from the 1960 to 1970 Census. The consequence for our study was to make it difficult to identify areal units that were

identical in boundaries from the 1960 to the 1970 Censuses.

Of course, least difficulty was found for counties, important political units outside New England and Alaska, and hence less likely to change. Of the 3,141 counties to be found in the U.S. in 1970, 3,102 comparable county units could be formed, consisting overwhelmingly of exactly comparable counties and a comparatively few units made up of sets of contiguous counties whose combined boundaries were comparable from 1960 to 1970.

Much more difficulty was found with Census tracts some of whose boundaries are changed from Census to Census to reflect shifts in population density. First of all, we could only use tracts in SMSA's that had been recognized in 1960, since those so designated for the first time in 1970 did not have tracts drawn in 1960. Tract boundaries are typically drawn when an area becomes recognized as an SMSA, according to rough guidelines that direct local Census tract committees to observe physical demarcations (when available) as boundaries (e.g. rivers, major highways, parks, and the like) and encompass roughly homogeneous areas with about 1,500 dwelling units and 4,000 residents. Clearly, a tract first defined in 1940 or even 1960 may have changed a great deal by 1970 and areas that were essentially unpopulated in 1960 may in 1970 house many thousands of residents. Each decennial census recognizes these changes by redrawing some of the tracts in each SMSA.

Of the 10,720 tracts that we finally used in our analysis, about

70% were exactly comparable in boundaries (or changed in trivial ways) in 1960 and in 1970. An additional 12% represent merges of tracts (usually pairs) that through such merges maintained comparable boundaries in the two censuses. An additional 18% are "roughly" comparable, encompassing areas that are 90% or more identical from one Census to the other.

Merged and roughly comparable tract units cover precisely those areas within an SMSA that experienced the greatest amounts of change in the period 1960 to 1970; that is why the 1960 boundaries of the tracts involved were changed, splitting tracts that had grown greatly in population and housing and merging those tracts that had experienced precipitous declines. Natural hazards that favor open country (e.g. tornados) tend to favor merged tracts, a fact of life that made our analyses of tornado effects especially tricky.

The details on the Census data base are given here to illustrate that Census areas are not necessarily fixed forever in boundaries. As a means for locating where disasters have struck over periods of time, tracts and even counties are not perfect units. Especially if a researcher is interested in very precise locations for natural hazard events, it would be much more useful to record such events in a permanent coding scheme, e.g. latitude and longitude. In this respect, an exemplary disaster data base is NSSFC's machine readable tornado file, about which more will be said below.

III: <u>The Disaster Data Base: Distant Encounters of the Sixth Kind</u>:

For the purposes of our research effort, we needed to identify all disaster events resulting from floods, tornados and hurricanes, taking place between April 1, 1960 and April 1, 1970 along with quite precise information on their locations in time and space. We also hoped to find reasonable damage and injury estimates that could be associated with each event, hopefully disaggregated by small areas as well as relief and rehabilitation effort measures, similarly disaggregated. We soon found out that there is no single source that contains all the required information with sufficient specificity: There are a variety of data sources, each of which suffers to some degree from more or less grievous faults. We also found out that we would have to abandon some of our data aspirations, particularly those involving disaggregation of damages and relief measures into small areas.

To begin with, there are literally thousands of events that occurred during the 1960's that <u>could have precipitated</u> natural disasters, but which occurred in sparsely populated places or were of minor physical magnitude even though occurring in a populous area. A natural hazard event (e.g. tornado, flood, etc.) that does no damage or inflicts no injuries is clearly not a disaster, by definition. For example, that National Severe Storm Forecast Center's tornado file enumerates more than 7,000 tornado events in the decade under study. The vast majority of these events are not natural disasters

because they neither inflict injury nor damage. Of this very large number only 24 were serious enough in the disaster sense to trigger a Presidential Disaster Declaration and only 129 were serious enough to be the object of a Small Business Administration declaration. Similar counts can be made of other types of potentially disastrous events: Most riverine floods cause little or no damage because they are either minor in extent or because they occur in places where there are few people and little in the way of property.

This distinction between natural hazard events and natural disasters is one which distinguishes between two types of natural disaster data bases. Thus the NSSFC tornado tape has as its units natural hazard events, while the American National Red Cross contains only natural disasters in its Chapter Reports files. . To be sure, it is not clear which unit is the more preferable for disaster research purposes, although it is clear that a more inclusive data base can always be culled for limited use while a more restricted data base cannot usually be enlarged.

Secondly, the variety of disaster data sources each takes a different slice out of the total set of events that might qualify as disaster occurrences. Some of the data sources confine themselves to only one type of disaster occurrences, as for example the tornado tape mentioned above. Others, such as the ANRC Chapter Reports are more catholic in taste, counting all events to which Red Cross Chapters responded and for which expenditures were made by Chapters.

The consequence of specialization are that it is necessary to go to more than one source for research purposes that encompass a variety of information about a variety of disaster types. In the end, we had to go to the following sources to piece together the information we desired:

On Tornados: The National Severe Storm Forecast Center provided an excellent tape, containing damage and injury estimates on all tornado events as well as location in terms of geographical coordinates down to the nearest minute.

ANRC Chapter Reports provided additional information on damage, but locational data was only approximate and on the level of counties.

SBA files contained data on counties declared as disasters with locational information on SBA loan recipients disaggregated down to the zipcode level.[1]

On Hurricanes: The machine readable files of the National Hurricane Center tracked the eye of each storm in geographical coordinates for periodic intervals as well as the width of the eye and certain other physical features of the hurricane events.

ANRC Chapter Reports were used to obtain county level damage and injury estimates along with SBA files (subject to the limitation described above).

On Floods: Here we found no machine readable files and no one source contained information on flood locations with any specificity below county levels.

ANRC Chapter Reports provided damage estimates on rough county level. The Hydrological Atlas and Water Supply Papers provided information on flood events but usually in rather gross locational terms, e.g. watershed locational.

[1]Unfortunately, the zipcode was of the last address of loan recipients, containing a number (unknown) of addresses changed from where disaster event was experienced.

SBA files were used to provide zipcode locations of last known addresses of flood loan recipients.

Flood hazard boundary maps submitted in compliance with the Flood Insurance Program were used to obtain likely locations of floods on small area levels (used in conjunction with SBA files in connection with floods designated as serious through sources cited above.)

In addition, the files of the N.Y. Times were searched mainly to make sure that there were no natural hazard events that slipped through undetected by any of the data sources mentioned above.

For our purposes, the main problem with the above data bases was their vagueness about where disaster events were experienced, with the noted exception of the NSSFC tornado tape. We are quite confident that we have the correct county locations of severe disasters, but, with the exception of tornados, our pinpointing of the locations of disaster events within SMSA's is a more or less educated, triangulated guess.

Not only are the existing disaster data bases vague on certain crucial points, such as location, but they are also not very consistent one with the other. For example, Table 1, presents correlations based on counties as units between NSSFC tornado tape estimates of tornado events, and resulting injuries with similar information contained in ANRC Chapter Reports. It should be noted that NSSFC counts tornado events, while ANRC files count tornado disasters and hence correlations should be high only on measures involving the severity of damage and injuries.

The coefficients (correlation coefficients) across the two data sets are displayed within the rectangle drawn on Table 1. The average size of these coefficients is distressingly low, especially on measures involving damage to property.[2] Agreement is high only on the number of persons killed, as represented by the very high coefficient, .81. About the best that can be said about this table is all the coefficients are positive indicating a low order of agreement across the two sources.[3]

Similar calculations for agreement across the other data sources result in about the same levels of consistency.[4] In short, the disaster data bases produce about the same level of consistency concerning damage and injuries from disasters that is characteristic of some of our poorer social psychological attitudinal tests. Indeed, this comparison may be more than an analogy since the ultimate sources of the data used for such estimates may be guesses concerning damages generated by amateurs and hence may reflect more their degree of involvement than accurate assays.

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[2] This is partially a function of the different units used in reporting. The NSSFC tornado tape provides dollar estimates broadly grouped while the Red Cross Chapter Reports provide an estimate of housing units damaged and destroyed.

[3] There is also the question of how much contamination is there between the two sources. If the NSSFC used ANRC Reports to "correct" their estimates (or vice versa) then the two sources are not independent.

[4] Reported more fully in J. D. Wright, P. H. Rossi, S. R. Wright and E. Weber-Burdin "Estimating the Long Term Effects of Tornados, Hurricanes and Floods" Social and Demographic Research Institute, Univ. of Mass. 1978 (Mimeo.)

Table 1

Correlations Among Tornado Variables From ANRC and NSSFC Files Aggregated to Counties

(N = 3102 County units)

NOTE: Decimal point suppressed

		NSSFC			RED CROSS						
		2	3	4	5	6	7	8	9	10	11
NSSFC	1. Number of Tornados	17	10	09	35	16	17	20	18	19	11
	2. Number killed		34	30	28	81	66	53	51	34	13
	3. Number injured			11	16	30	33	26	30	24	10
	4. Total $ Damage				10	33	31	19	35	22	04
RED CROSS	5. Tornado Reported					31	36	42	34	36	20
	6. Number killed						80	64	61	40	14
	7. Number injured							75	76	61	26
	8. Red Cross Costs								83	68	23
	9. DU's destroyed									77	25
	10. Major damage to houses										69
	Minor damage to houses										

Summarizing our experiences with trying to use the existing disaster data bases for our purposes, we can say that at minimum it has been a very frustrating experience. Researchers are notoriously greedy and self centered and are clearly never satisfied with any existing data set. There is no particular reason why the existing data bases should be tailor-made for our purposes. Hence part of our frustration ought to be discounted heavily. What is serious, however, is that our explorations into the disaster data bases brought to light serious deficiencies in more important features of more general interest to the disaster community of agencies, researchers and policy makers, as follows:

First, with few exceptions, the data bases are hard to use and unnecessarily so. Secondly, there is entirely too much reliance on guesses, unguided hunches and coarse approximations, especially in the estimation of damages and injuries resulting from disasters and also in their locations. Finally, lack of standardization in basic procedures (e.g. using the same locational codes) considerably increases the problems of merging data sets for purposes other than their particular administrative roles.

IV: Implications for Disaster Data Base Policy:

The data bases upon which our research rested were not collected, obviously, for the purposes to which we wished to put them and hence our frustrating experiences with trying to use partially reflects our ambitions. The ultimately ideal data base for our purposes would have been most likely far beyond the agencies' capabilities and certainly far beyond their interests to produce. Yet there are some steps that can be taken by agencies which at minimum cost would make their data bases more usable to these researchers and conceivably to others. There are also additional steps that can be taken, at somewhat greater cost, that would help out ever further.

These recommendations involve two steps that can be taken by the agencies in question without much additional cost and a third step that involves the construction of a new installation, a disaster data archive. The first recommendation involves the computerization of existing data bases in such a form that would facilitate the transfer of information from agency to agency and from agencies to researchers. Although most agencies have either computerized their files or are about ready to do so, it is important to stress that getting files on tape can be done in ways that restrict outside-agency applications or in ways that facilitate such use. The restricted forms should be avoided, if at all possible.

Perhaps the best example is the excellent data set available from the American National Red Cross. These reports are currently

all on tape, but not in numeric codes. This form makes it easy for ANRC to retrieve the text of Chapter Reports but cannot be used without tedious programming for research purposes, Futhermore, the data are stored on the tapes in an inefficient form even for ANRC's own purposes. For a rather modest investment in software, ANRC can easily store its reports in a form that would make it easy for others to use them for research purposes.

A second step that agencies could take would be toward standardization of data bases. Standardized procedures ought to be used for the collection of raw observations. For example, damage and injury estimates ought to be guided by explicit procedures. At least the source of the estimates ought to be indicated (e.g. whether from newspaper reports, estimates of public safety officials, and so on) so that others may judge whether the sources substantiate the claims made. For very little additional effort, more precise locational data may be obtained from field observations, preferably in the form of geocodes.

Standardized procedures, formats, codes, etc., should be used wherever possible, including the adoption of such generally recognized procedures as using the Federal Information Processing Standards codes for states, counties and other places. From our viewpoint the most pressing need is for standardization in defining and retaining in records the actual locations of disasters. The data bases, with the exception of the NSSFC's tornado tapes, do

not allow one to locate disasters in space within even such gross areal units as counties and cities. Of course, part of the problem lies in the ambiguous location of natural hazard events, especially severe storms such as hurricanes, but accurate counts of damages and injuries by counties would be a sharp step forward from the present situation of imprecision.

Incidentally, we believe that there are non-research needs that would be served well by better locational information. For example, state 201 planning efforts would have been aided if it would be easy to reconstruct from existing files what has been a state's disaster experiences over a few decades. Or, the Flood Insurance Program would be helped if each locality had a better sense of what its past disaster history has been. At present controversy over flood plain management required by the Flood Insurance Program is certainly aided by the fact that existing residents' memories do not go back far enough to cover the significant disaster events of the past.

A third step that could be taken involves the expenditure of some additional funds, especially in the form of a heavy initial capital investment. This step involves the founding and maintainance of a new institution that would serve as an archive with the mission of collecting, evaluating, cataloguing and disseminating data on the incidence, location and sequelae of natural hazards phenomena. It is beyond our competence to assess what should be the size of such an investment and whether it would be of utility to more than the research community. It would certainly be costly to start up such an institution and require long term committment to capture whatever

benefits it would yield. We do believe, however, that there are some policy benefits that might accrue. For example, hazard risk assessment would be considerably strengthened by better historical records on the risk experiences of communities and larger areas. Damage estimations would be less an exercise in conjecture if we knew more precisely the relationship between the physical severity of natural hazards events and damage sequelae, an exercise that would require extensive accurate historical series. Finally, federal policy would be better off, if based on an appreciation of the full range, shape of the distribution and central tendency measures for natural hazards events.

"Existing Data Sources: In Inventory," excerpt from

NATURAL HAZARDS DATA RESOURCES: USES AND NEEDS

Susan K. Tubbesing, Editor

Program on Technology, Environment and Man
Monograph # 27

Institute of Behavioral Science
University of Colorado
1979

CHAPTER II

EXISTING DATA RESOURCES: AN INVENTORY

That our country is growing increasingly vulnerable to natural hazards has been recognized for a number of years (White and Haas, 1975). Increased development of coastal regions, flood plains, and seismically active areas, has caused the threat of disaster to become widespread. Fortunately a number of actions or adjustments can be made to mitigate the potential impacts of such extreme events. The adoption of land use patterns which reflect concern for geologic and atmospheric hazards; emergency preparedness planning and public education efforts; structural modifications; and forms of individual behavior, such as the purchase of insurance or adoption of flood-proofing practices, are all adjustments which can lessen the impact of an extreme event. However, these activities require data and information often of a multi-disciplinary nature. These data are scattered in many agencies and in general were collected for purposes other than natural hazard identification or evaluation. The potential users--city planners, engineers, actuaries, emergency relief groups and others--may experience difficulty in finding the data they need.

In preparation for the Workshop, Robert Alexander of the U.S. Geological Survey and James Lander of the National Oceanic and Atmospheric Administration compiled a preliminary Inventory of sources of data relevant to natural hazards which presently exist in a number of federal agencies. Appendix IV contains a copy of the letter and questionnaire which were sent to all federal agencies with hazards data collection responsibilities. The result, A Partial Inventory of Federal Agency Data Resources for Natural Hazards Assessment, was distributed in preliminary form to all those participating in the Workshop.

The completed Inventory is expected to appear as a separate publication under the joint sponsorship of NOAA and USGS and will serve as "a guide through the maze of agency holdings of relevant data" (Alexander

and Lander, 1978).

It is our intention, in this chapter, to present only a brief summary of the Inventory using sample entries to develop a rough outline of the existing data system.

Organization of the Inventory

The Inventory focuses on natural hazards data bases broadly defined to include geological and geophysical agents, economic data including losses, location of critical facilities and lifelines, and demographic data. The authors have not considered hazards due to human activities such as oil and chemical spills, radiation, fires, accidents, etc., even in those cases which may have been triggered by natural events.

Alexander and Lander note that they have classified each data resource into two resource categories and four types of data use. The data resource categories are I) primary data bases, that is, those that are formally constituted to supply data to users on an operational basis, usually in computerized format; and II) secondary or referral data sources, i.e., agencies with disaster-related administrative or research programs, special libraries, bibliographies, or abstracting services. The four user-related categories are:

1. Data used to identify risk--including data descriptive of the environmental factors underlying the hazard or potential disaster.
2. Data used to evaluate risk--including data on the location of potentially vulnerable populations, critical facilities, buildings, etc., as needed to determine the extent to which an extreme natural event would pose a threat to life and property.
3. Data used to evaluate damages--including those data necessary to describe damage and loss to persons and property.

4. Data used to plan for disaster--Data used to formulate alternative adjustments or plans for disaster mitigation, for example, the strengthening of building structures, evacuation of population, plan for future land uses in accordance with risk or natural hazard or disaster. (See Table II-1.)

The preliminary Inventory contains 124 data sources. When published the Inventory will assist the hazards data user by providing a concise listing of which data are collected and stored by which agencies in the federal government including whom to contact for more specific information pertaining to cost, accessibility, etc.

No attempt was made to include data resources located within state and local governments, universities, nor those which may exist in the private sector.

Agencies Responsible for Data Collection

Among the eleven federal departments, nine have at least one agency or program which has as one of its activities the collection of hazard-related data and at least twelve federal independent agencies have hazard-related data collection responsibilities. Some Departments, as Agriculture, Commerce, and Interior, have a great many programs which deal directly with hazard management or response. For example, within the Department of Agriculture, the U.S. Forest Service maintains the West-wide Avalanche Data Network and the Soil Conservation Service collects and maintains Water Supply Data and a Flood Hazard Analysis.

The Department of Commerce maintains hazards data through a wide range of programs which function primarily within the National Oceanic and Atmospheric Administration. NOAA's Environmental Data and Information Service maintains an Earthquake Data File, an Earthquake Effect File, Strong-Motion Data File, Seismograms, Tsunami Mareograms, Coastal

TABLE II-1
EXISTING DATA RESOURCES
AND TYPE OF DATA USE

Data Resource Name and/or Source Agency	Data Resource Category: I Primary	II Secondary or Referral	Type of Data Use: 1 Identify Risk	2 Evaluate Risk	3 Evaluate Damages	4 Plan for Disaster
Satellite & Other Remote Sensing Data, EROS Data Center, USGS	x			x	x	
Global Seismology, including NEIS, USGS	x	x	x			
Earthquake Hazards Reduction, USGS		x	x	x	x	x
National Landslide Information Program, USGS		x	x	x	x	x
National Water Data Storage & Retrieval System (WATSTORE), USGS, WRD	x		x			
Water Data Sources Director, USGS		x	x			
Master Water Data Index, USGS, NAWDEX	x		x			
Volcano Hazards Program, USGS		x	x	x	x	x
Geological Hazards Information & Notification, USGS		x	x	x		x
Guide to Obtaining Information From USGS, 1978		x	x	x	x	x
Environmental Geochemistry & Health, USGS		x	x	x		

Bathymetry, and Photograph Files recording earthquake and tsunami damages. NOAA's National Climatic Center maintains statistical files on climate, tornado, lightning, hurricane and extreme weather, flood data through monthly Summaries of Flood Readings on Daily River Stages. In addition to these and many more data bases NOAA operates OASIS, a computerized data base referral service, and ENDEX, which contains references and descriptions of approximately 10,000 data bases in fields of meteorology, oceanography, biology, geology, geophysics, and solar terrestrial physics worldwide.

The National Weather Service arm of NOAA contains an extensive array of historical references to hurricanes, cyclones, and tornadoes. The National Hurricane Center in Coral Gables, Florida maintains a Hurricane Data File (HURDAT) which includes a computer listing of Atlantic tropical cyclones from 1886-1977 including storm positions, maximum wind speeds and surface pressure readings. The National Severe Storms Forecast Center in Kansas City, Missouri maintains a Tornado History Data File which lists over 17,000 tornadoes and includes date, time, latitude, longitude, and those states and counties which were affected.

These represent only a small sample of those data sources listed in the draft Inventory.

In addition to listing data resource agencies and providing general descriptions of the types of data available (e.g., historical statistics on tape or computer card, maps, photographs, etc.), the Inventory will provide information to enable the user to determine quickly the accessibility and cost of the information. For example, the entry for the National Flood Insurance Program Master File maintained by the Federal Insurance Administration (FIA) in the Department of Housing and Urban Development (HUD) includes the fact that unlimited information is available from the files upon request for those communities in the 50 states

and territories which are participating in the National Flood Insurance Program. The entry specifies that the following information is available:

> Population of hazard areas.
> Number of structures in hazard areas.
> Maps delineating special flood hazard areas of communities. Statistics can be broken down by community if needed. Also available, number of insurance policies in force and amount of coverage. Tape copies available/list of identified communities available. Unlimited availability on request. File updated regularly.

Another major source of hazards data is the Department of Interior. Through its numerous departments, services and agencies, it maintains information on earthquakes, floods, hurricanes, landslides and volcanoes. The preliminary listing includes 26 programs which collect hazards data, 15 of which are in various offices of the U.S. Geological Survey. The USGS Office of Earthquake Studies operates the National Earthquake Information Service, the Worldwide Standardized Seismograph Network, and the Albuquerque Seismological Laboratory as part of its comprehensive Earthquake Hazards Reduction Program. Output includes scientific and technical reports, maps and data, for which bibliographies are in preparation. The entry notes that certain data are released to the public through the Environmental Data and Information Service of NOAA.

The National Water Data Exchange (NAWDEX) in USGS maintains the Master Water Data Index. The Inventory provides the following information about the Index, the parameters of its data base, availability and cost for use:

> Information on nearly 200,000 sites for which water data are available; 318 source organizations; types of data available; period of record available; major parameters measured; frequency of measurement; media of availability; geographic location of sites. Sources are water data collection agencies. Nationwide United States and Canada, capabilities exist for worldwide entries. Reference: USGS Open File Report 78-183. Computer searches on types of data available and geographic locations, or by specified criteria; printed lists; summary counts, site location maps. Availability unrestricted at cost

of computer searches and providing computer listings.

A particularly valuable feature of the Inventory is the inclusion with each of the entries of a name, mailing address and phone number which facilitates access to and use of the existing data resources.

Conclusion

A sense of agreement existed among those participating in the Workshop that before any attempt is made to improve the overall usefulness of hazards data it will be necessary to determine what data are currently collected, in what format they are stored, whether they are accessible, and the cost to users. This must be done before further analysis can be carried out to identify areas in which duplication, omission or inaccessibility prohibits their efficient use.

It is anticipated that publication and wide distribution of an Inventory of federal data resources will facilitate these analyses and ultimately contribute to the overall usefulness of hazards data resources (see Recommendation 7).

Appendix H

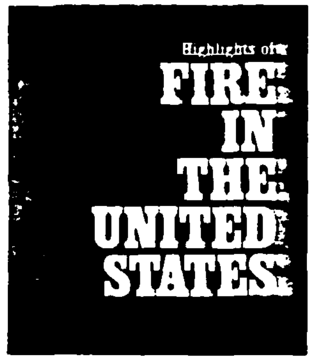
Excerpt from

Highlights of FIRE IN THE UNITED STATES

Deaths, Injuries, Dollar Loss and Incidents at the National, State, and Local Levels In 1978

SECOND EDITION

federal emergency management agency / U.S. fire administration



Deaths, Injuries, Dollar Loss, and Incidents at the National, State, and Local Levels in 1978

legislation, and target research projects. For example, the Consumer Product Safety Commission, in considering flammability regulations for upholstered furniture, used NFIRS data as well as National Fire Protection Association data showing that upholstered furniture is the most common product first ignited in fatal residential fires. NFIRS data dealing with causes of mobile home fires has shown the U.S. Department of Housing and Urban Development that the provisions of the 1976 Federal Mobile Home Construction and Safety Standard are helping reduce fire problems in those homes.

The Center for Fire Research, National Bureau of Standards, has used the national fire statistics to set priorities and plan its research. The results of that research, in turn, contribute to our understanding of the nature of the products, construction and design features, and other factors which impact the ignition and spread of fires.

Other organizations also are using fire data to improve products, codes and standards, and fire protection equipment. The National Fire Protection Association, Boston, Massachusetts, is using NFIRS data while developing fire models and for supporting their fire protection standards committees.

Many fire departments have developed specific uses for their data—scheduling shifts, targeting inspections and public education at unique local problems, preparing annual reports, arguing for budgets, etc. These ideas are being shared among departments participating in NFIRS by means of the *NFIRS News*, at the annual NFIRS Users Conference attended by each state, and at conferences now held by a number of individual states for their participating departments.

In addition, both the national fire data figures and figures from local communities where they are available are being used to give the general public a greater sensitivity to dangers from fire.

Reporting fire data and understanding the nature of the fire problem is an essential step in reducing the Nation's fire losses. When all levels within the fire sevice take this step, we will be better able to prevent injuries, loss of life, and the destruction of property in the days ahead.

A Few Words On Data Sources And Data Accuracy

It is important to make clear the nature of the data on which our analysis is based. In measuring the overall size of the U.S. fire problem, we can place most confidence in the fire death estimates. We place somewhat less confidence in estimates of fire incident rates, followed by the estimates of direct dollar loss. The injury estimates for both civilians and firefighters are the least reliable statistically but are presented to give at least a rough idea of the seriousness of this part of the problem.

Fortunately, we now have a much better understanding of the specific characteristics of the Nation's fire problem that we need to know to target and evaluate programs. This progress has occurred because of the expanded scope of the National Fire Incident Reporting System on which much of our analysis is based. Fifteen states had submitted at least one full year of data and the NFIRS data base included more than 1,000,000 fires (440,000 from 1978 alone) when we began our analysis for the second edition of *Fire in the United States*. Thirty-eight states, plus the District of Columbia, are at various stages of developing NFIRS at this time, so the future holds even further promise for improvement.

We have also expanded our analyses of data from the National Fire Protection Association, the National Center for Health Statistics, and other sources. We use data from sources other than NFIRS for three reasons. First, no single source has all the information we need. Second, we often can make better estimates by combining data from two or more sources. And third, we can determine the reliability of our estimates better when more than one source is available to cross-check accuracy. This cross-check is especially valuable now, while the United States is still in the early stages of developing an improved fire data system and while we are establishing baseline information against which future changes can be measured.

Sources of fire data used in this report include the following: National Fire Incident Reporting System data from California and Ohio for 1976 through 1978; NFIRS data from Alaska, Maryland, Minnesota, Missouri, New York, and Oregon for 1977 and 1978; NFIRS data from Illinois, Michigan, Montana, Rhode Island, South Dakota, Utah, and Wisconsin for 1978; State Fire Marshal annual reports from many states; National Center for Health Statistics death certificates; National Fire Protection Association fire department surveys for 1977 and 1978; and National Fire Data Center surveys and special studies on selected topics.

For each specific topic the latest accurate data available was used for analysis. Most of our facts and figures describe the fire problems of calendar year 1978, although some are from 1977 where 1978 data was not available yet. We have indicated in the text and on the charts and tables the sources and dat.~ of the data presented so that anyone quoting the findings or doing further analysis will know what base they are using.

★U.S. GOVERNMENT PRINTING OFFICE: 1980 O—721-440/238

Recommendations from

NATURAL HAZARDS DATA RESOURCES: USES AND NEEDS

Susan K. Tubbesing, Editor

Program on Technology, Environment and Man
Monograph # 27

Institute of Behavioral Science
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1979

Recommendations

The final chapter includes a discussion of each of nine Recommendations which grew out of the Workshop. A number of quite specific suggestions are made for action to be taken to reduce possible redundancy of effort and improve accessibility of data resources to users.

Although the Recommendations have application for all agencies which have hazards data collection responsibilities, it was the hope of all those who participated in drafting them that they be given careful consideration by those who will bear administrative responsibility for directing the new Federal Emergency Management Agency.

1. RECOMMENDATION: The new Federal Emergency Management Agency (FEMA) should take on the responsibility to facilitate the exchange and use of hazards information.

2. RECOMMENDATION: Guidelines should be established for the coordination of mobile monitoring of meteorologic, seismic, and geologic conditions in the predisaster situation. This effort should be the responsibility of the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey (USGS).

3. RECOMMENDATION: Guidelines should be established for aerial photography, remote sensing, and ground surveys to be carried out in the immediate postdisaster situation, coordinated by the Federal Disaster Assistance Administration.

4. RECOMMENDATION: The Federal Disaster Assistance Administration (FDAA) should establish an interagency task force to evaluate existing data bases, identify areas of data incompatibility, possible duplication and/or omission and make suggestions for natural hazards data base improvement.

5. RECOMMENDATION: The U.S. Geological Survey should, within the next year, develop a national program to identify and delineate geologic related hazards (earthquake, volcano, landslide and subsidence) and a strategy for implementing such a program utilizing all federal, state, academic and private resources as appropriate. Such a program, in conjunction with NOAA's National Geophysical and Solar Terrestrial Data Center's hazard delineation activities would provide a basis for natural hazard identification, delineation, and risk assessment.

6. RECOMMENDATION: The design of national simulation models should be undertaken, utilizing interagency data and technical assistance, and coordinated by FEMA.

7. RECOMMENDATION: The draft Inventory compiled in preparation for the Natural Hazards Data Resources Workshop by Robert Alexander of USGS and James Lander of NOAA should be completed and distributed among user groups. The Inventory should be designed as a problem-oriented instructional booklet, using an attractive technical assistance format.

8. RECOMMENDATION: The Federal Disaster Assistance Administration should re-examine the 1971 inventory in Some Guidelines for Developing an Office of Emergency Preparedness Clearinghouse for Emergency-Related Research, Volume II, Appendix C, which was prepared for the former Office of Emergency Preparedness by Charles E. Fritz to determine the availability and nature of natural hazards data sources which are maintained by organizations in the private sector.

9. RECOMMENDATION: In order to facilitate the transfer of existing information on natural hazards planning and improve awareness of natural disasters on the part of state and local officials the federal government, under the leadership of FEMA or existing preparedness agencies such as the Federal Disaster Assistance Administration and with the support of other appropriate federal agencies, should undertake a training program for the use of hazards data by local, regional, and state groups which have responsibility for risk assessment, disaster avoidance, mitigation response and recovery.

A brief discussion of each of the above, including those steps necessary to translate the recommendations into action, is included in Chapter VII. In a number of cases suggestions have been made as to which agencies might bear primary responsibility for implementation.

Appendix J

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
PERSPECTIVES ON NEEDS FOR AN AVAILABILITY
OF SCIENTIFIC AND TECHNICAL INFORMATION*

by
D. Earl Jones
Chief, Architectural and Engineering Branch, HUD

I would like to start by emphasizing that Earl Jones was asked to speak to you as Earl Jones, not as an official representative of HUD. Anything I may say is my own idea and should not be interpreted as a HUD position or policy.

May I present some statistics. Let me take you back a few years. About ten years ago I looked at the subject of natural hazards and identified some sixty of them. Losses due to them were rank ordered by dollar value in two ways (See Table 5-3): (1) in terms of average annual damages; and (2) in terms of the probable maximum annual damage caused by each of the listed hazards. These loss values wer obtained partially by subjective judgments and partially from documented information. They are essentially ballpark figures. No one figure was thoroughly researched, although many are based upon very extensive information. Each figure is a conservatively low estimate. The losses listed total more than $60 billion per year, a significant detraction from society's national wealth.

Losses caused by some of them have a potential to trigger a Presidential declaration of disaster. Such possible losses total about $15 billion. Actually, only 22 percent of natural hazard losses in the U.S. could become

*(From Committee on Emergency Management, Commission on Sociotechnical Systems, National Research Council, Presentations made at the First Meeting of the Committee on Emergency Management, April 30-May 1, 1981, Washington, D.C., June 1981.)

Presidentially declared disasters, triggering many Federal and other public agencies' programs.

Should we have 50,000 people killed in Washington, D.C. this afternoon, it would still be a news headline six weeks from now. But we are getting over 50,000 people per year killed on our highways, with few associated news headlines unless there is some spectacular fiery crash, which is given short-term local news attention. Obviously, our society can absorb a large dispersed loss. The great threat to our society, however, is a major locally concentrated loss. Improper private and public policies can multiply the actual impact of natural hazards losses in our society. If you look in the column labeled "Probable Maximum Annual Damage (PMAD)," [See Table 5-3 on page 5-5] you will see one number that stands out, $280 billion. Such a loss could result from a great earthquake striking a major metropolitan center, followed by fire. The post-earthquake fire risk probably ranges between a one-in-three and one-in-six chance that if we have such an earthquake, it will be followed by fire. For example, the losses in the San Francisco fire after the 1906 earthquake were more than six times the earthquake losses. A current repetition of such a fire disaster would see practically all fire loss covered by insurance, although virtually none of the earthquake loss is insured. The direct impact of such an event on the casualty insurance industry would be quantifiable and great, but the total national impact would be greater. The insurance companies themselves and the reinsurers that cover the fire

risk back their coverage with insurance reserves. Reserves are not liquid assets, idle cash assets sitting in vaults and instantly available to pay claims. Instead, they are invested in the stock market, in the bond market and in the tremendous secondary mortgage market. If insurance companies had to reimburse $100 billion or more in claims within a 12-month period, they would first dry up available lending capital. Then they would begin liquidating their invested reserve portfolios. On a $100 billion scale, they would overstress the stock, bond and secondary mortgage markets. The total impact on our society would be far greater than from a major loss in one geographic region. Literally, there is a potential for collapsing the entire economy.

This is an illustration of how we sometimes do things that will multiply the net societal impact of disasters. We alluded to this in blue papers published for implementation of the Earthquake Hazards Reduction Act of 1977. Perhaps we can find ways--and there are many possible ways--to avoid such consequences and minimize potential societal losses.

Let us now change the subject. Let's suppose that in the year 2012 there will be a disastrous flood in a major metropolitan area. Between now and 2012 we will experience 31 years of average annual hazard losses of $60 billion per year (current value). In other words, we will experience a couple of trillion dollars worth of natural hazards losses in this Country before 2012. It would be nice if, instead of enduring such loss, we might recapture some part of it and convert it to productivity, contributing to the accumulation of national wealth.

This should be our real objective in trying to reduce disaster losses. Although lives are necessarily our greatest individual concern, we should address at least equal concern toward the stability, health and welfare of our total society. We have an opportunity to do so. This opportunity is called "loss mitigation." We are just learning how to mitigate losses, and do not yet have all the answers.

FEMA has taken many steps to stimulate thinking about mitigation. The National Science Foundation and the National Research Council also have been trying to stimulate it. Mitigation is vital, as evidenced by figures mentioned above. Most importantly, the beneficial effects of mitigation are cumulative and increase exponentially over time. The central question becomes, "How can we best mitigate?" This Committee has a basic focus on how the sciences and the professions in a post-disaster situation may best help alleviate immediate losses and mitigate future losses. May I submit to you that the best approach to reducing these kinds of losses--there are many other kinds also--is to start now, before the future disasters, to do something to mitigate potential disaster losses that may occur in 2012 or 2022, or whenever. How can we do this? It can be done incrementally, not simultaneously nation-wide. I do not think we can achieve it with carefully prepared, voluminous plans giving specific post-disaster assignments to each individual in the society. Such plans can only be developed at a specific time, based on current technology and for specific local conditions. One of you earlier made the point that if we have a power outage during a disaster, many on-line computers will be out of service, crippling response

capabilities. Thirty years ago that was not a consideration. Times have changed; technology has changed; society has changed. I submit to you that the probability of a major disaster impact in a specific locale is low, but the probability of one occurring somewhere in the Nation is much greater. Observers from a local level thus perceive a low loss probability. They will think, "Mitigation can wait; let us address the immediate local crisis." The real challenge for mitigation, however, is to stimulate incremental, assured, long-term, sustained mitigation--with emphasis on sustained. We are not now acting to reduce the threats from many potential disaster problems we face. In reality, true action needs are actually falling into cracks between programs and between disciplines.

One problem is that we, as scientists and engineers, are conditioned to respond to causes and effects. Cause and effect are defined, but scale is not addressed. Scale can be tremendously important. For example, in the Rapid City flood several years ago, there were 114 lives lost. The next day, it was business as usual throughout the City, except in an impacted area which was only six percent of the community area. There were sufficient vacant properties so that there were no serious displacements of persons other than those who had been directly impacted, and they were fewer than six percent of the local population.

For contrast, let's examine another locale. If a major flood event were to strike New Orleans, much of a large community would be seriously affected. The week after the Rapid City disaster, you could hire a contractor to go to the lumber yard, obtain building supplies and repair a damaged property for about the same price that similar repairs would have cost two weeks before the disaster. After a major disaster in New Orleans, there would be insufficient local resources--labor, materials, etc., to rebuild completely in less than two years, and repair costs would skyrocket. This emphasizes the importance of scale. In New Orleans, due to the massive scale, reconstruction, repair and replacement costs would be three or more times the normal pre-disaster construction costs. A $75,000 current value house in New Orleans, perhaps 45 percent damaged, might cost over $100,000 to rehabilitate. This is the scalar factor at work. The scalar factor is significant because we base average annual damage forecasts upon everyday pricing mechanisms. If we would evaluate potentially severe impacts upon large portions of communities, we should multiply presently anticipated losses by a factor between two and four. The larger projection would be more realistic. By failing to consider the scalar factor, we are basins important decisions on estimated average annual damages that may have an obvious 100 percent error.

In 1972, the Engineering Foundation was concerned about some of these questions. They recognized that there are so many different natural and manmade hazards that we should be looking at them as a

group, rather than trying to address and avoid each one individually. It was evident that if you do something to mitigate the effects of one hazard, it may significantly mitigate the effects of other hazards, as many of the hazard impacts are interrelated.

There is no location in the U.S. that is exposed to only one hazard. When we look at one particular cause of disaster, we may easily overlook the full range of costs and benefits attributable to integrated mitigative actions. If we are attributing too little benefit to an action, there may be no action. As a result of the conference stimulated by the Engineering Foundation, large segments of the sciences and professions are now thinking in terms of multiple hazards, recognizing that we should be responding to all causes of loss in the total picture.

There is a challenge to pure and applied scientists to look beyond phenomena and their causes and effects, and to focus on reducing the overall impacts on our society. This sometimes surfaces the unexpected. As an example, about 50 of us once sat around a room with Gilbert White in Chicago, to develop a recommendation to what ultimately proved to be the Federal Insurance Administration, the year before the FIA Act was passed. The Government desired

guidance to identify a basic regulatory norm for local participation requirements in the expected National Flood Insurance Program. Each attendee's suggestions and comments were solicited. A few persons felt that we should identify the one-year flood; quite a few more felt that we should be looking at the 10-year flood; some thought that we should stay with the Standard Project Flood, which has been defined by General Bill Whipple as a flood that can be expected to recur "on an average of once every 10,000 years or less frequently." The ultimate consensus was that the basic regulatory norm should be the 100-year flood. The Federal Housing Administration (now part of HUD) had already gained acceptance of that level of regulation by most builders' groups in the U.S. That norm is now well accepted.

In retrospect, that was a decidedly subjective decision. The weak basis for its selection gave me concern even though I was one of its more outspoken supporters. Subsequently, I undertook some research probes and determined that the 100-year flood is a proper regulatory norm in many situations, but that it can get you into trouble in others. In some places, if everything is built to the 100-year level, a larger flood may have catastrophic consequences. For example, before one eastern river was "controlled," the 200-year flood level was 16 feet higher than the 100-year water level, with much greater average flow velocities. A public housing project was built there at the 50-year flood level, but after a 100-year

flood some of its foundations could not be found. A similar catastrophic loss would have occurred from a 200-year flood if the buildings had been built at the 100-year regulatory norm level. For the conditions along this eastern river, the minimum floodplain occupancy level should have been above the 140-year flood elevation to avoid a potential catastrophe.

There are other places where flood risks are at the opposite extreme. Park Forest, Illinois, is an example of these. The 100-year flood there is six inches deeper than the 10-year flood level, but the 200-year flood is only three inches deeper than the 100-year flood. This identifies a non-catastrophic risk, for which different loss management approaches are proper. In Park Forest, we can build safely on ground that is at the 10-year flood level; with the first floor a standard minimum of eight inches above the outside ground, and standard six-inch high protective slopes around the building, the floor level will be well above the 500-year flood level and the building will both offer a sound risk and be accessible at all times by emergency equipment.

In view of the foregoing, we cannot justify saying to the people in Park Forest, "You can't build on the 68 percent of your community that is subject to flooding by the 100-year flood."

These contrasting examples clearly illustrate why we should avoid seemingly simple solutions before establishing that they indeed will assure sound and uniform treatment. It also is of interest to note

that in the 16 years since adoption of the 100-year frequency regulatory norm, we have been unable to secure flexibility in its administration to accommodate the cited risk variations. The initially weak best recommendation is now cast in concrete and that concrete has hardened like diamond.

Approaches to mitigation of other natural hazards losses similarly require sound regulatory flexibility. They should not be similarly cast in concrete in a dynamic society that introduces things like computers, and nuclear power--changes not just in our society's technology, but also in its philosophies, perceptions, understandings and regulatory systems.

MORSE: If you had to make an estimate of how much construction is going to take place in the next 20 years, compared with the last 20 years, haven't we already built most of the things that we are going to build for a while? How much do you change, if you change a standard at this point in a lot of areas?

THIEL: I can give you one piece of data on this. We did a study some years ago trying to find out what the net change would be if you stopped occupying the 100-year flood plain, stopped putting additional occupancy in places exposed to "Modified Mercalli 9" intensities. We basically found that on the earthquake side that in 30 years we could decrease the annual expected loss by about 11 percent and for floods by 25 percent. Once you occupy a site like my house--it is coming upon its 200 birthday next year--the structure often has a very long lifetime compared to the occupancy level, but there is significant turnover.

MORSE: But the average is far, far less than that--for average structural life.

THIEL: Indeed, but anticipated structural life is sometimes difficult to estimate. And once you occupy the site, there may be a succession of structures. Second, when Earl Jones talks about construction-related issues, recognize that you can do an awful lot to an existing hazardous structure to reduce or mitigate damages from possible or probable future exposures--often for very small amounts of money. To give you an example: He put together what we call a wet flood-proofing approach. That approach costs only about one percent of the initial cost of the structure, but reduces the amount of damage from 55 to 88 percent, depending upon the character and degree of flooding experienced. That is a very small initial incremental investment. And most of it can be retrofit.

WILKERSON: There are two things here that ought to be mentioned. One, we have lost sight of that one-third of public damage unit. If you can show me how to keep an asphalt road surface from floating, then I am ready to build in the flood plain and accept it as a loss. The other point is that in high growth areas we need flexibility on the low side of the 100-year flood plain. What I need in north Hillsborough County is to build in the 10-year flood plain--because given the projection for growth in the next 25 years, the 100-year incident will be occurring every 10 years, because of increased storm water runoff.

JONES: This is another factor that does not get cranked routinely into normal, everyday risk management decisions. If you start developing a community at the bottom of a mountain, where the steam comes off of the mountain and runs into the river, you may be in a risky place. If the community then expands up the mountain and development replaces heavy forest

duff and vegetation, which intercept, absorb, hold, and retard runoff, and development produces carefully graded lots with curbed streets racing run-off into storm inlets and thence into pipes that move it downstream even faster, runoff water may "pile up" in the flatter urban area at the bottom of that mountain. Communities that began next to water and later developed upstream and uphill have found themselves in such trouble, nationwide. For example, after World War II, Dallas, Texas, initiated a tremendous street improvement program throughout the city. Almost all unpaved streets were then paved--with curbs replacing roadside swales which previously stored as much as 40 acre-feet of runoff before significant outflow occurred. Afterwards, a heavy dew would flood formerly flood-free areas. Places that had not been flooded in tens of years were flooding as often as two or three times a year--just because unattenuated runoff was being brought to them more rapidly without provision of additional outfall capacity. This is the experience that prompted the concept of "runoff management," published in 1971, which has changed urban drainage design practices internationally.

My comments reflect personal reactions to things that I heard here this morning--the perspectives, the involvements, the important peripheral considerations. It is to these peripheral dimensions and interfacing conditions that you may wish to respond. We cannot minimize the fact that we are trying to stimulate a societal response--not a response of a committee or a particular governmental or interest group. There are more than 15,000 communities in our country. Each has responsibilities and liabilities. Their responsibilities and their authorities are directly granted them by the States, usually through general

enablements. In the final analysis, each community has police powers permitting it to protect the public health and safety. Each has reasonable authority to adopt and enforce rules, regulations, ordinances and codes that directly affect public health and safety. Each has virtually no authority to protect individual health, safety, or investment on privately owned property, although they have total authority on publicly owned property. These communities have often operated in the tradition of English Common Law, where the King can do no wrong. He can't be sued. This is changing. A half dozen case decisions, upheld by the U.S. Supreme Court, could change the total operating atmosphere for American communities; in fact, it could turn topsy turvy our concepts of public liability.

THIEL: Some of those decisions have already been reached for Federal officials--that now the King can do no right, rather than that the King can do no wrong.

JONES: On the other hand, there is a vast lack of awareness around the Country that a couple of years ago a U.S. Supreme Court decision held that a local community, county or state official is individually answerable, individually vulnerable to litigation--tort claims--for his errors or omissions.

THIEL: This has basically been extended to apply to Federal agencies.

NATURAL HAZARDS CONSIDERATIONS, PROBLEMS & QUESTIONS

About thirty natural hazards cause damages, displacements and loss of lives throughout our Nation every year. Direct natural hazards costs to the Nation are estimated as about one percent of the Gross National Product and are increasing. Their indirect costs have not been comprehensively estimated.

Despite large governmental and private expenditures for natural hazard control works, losses attributable to natural hazards continue to increase. There is some evidence that some works intended to minimize or prevent losses may in the long run aggravate them. Past efforts to provide structural protection against natural hazards losses have not always been coordinated with other possible actions and approaches to effect maximum loss mitigation. Although instant unidirectional loss mitigation solutions are appealing, appropriate incentives, imaginative uses of depreciation and taxation, and other low-profile actions taken over a period of time may be equally important, and essential to achieve desired loss mitigation results more economically. Most importantly, non-structural loss mitigation alternatives may have effective and practical application where structural protection is economically unjustifiable.

Compassionate assistance to disaster victims is in keeping with our finest American traditions, but compassionate aid may be inhumane if it over-obligates the individual. And it may be altogether wasteful if it forces cosmetic repairs without prior correction of serious underlying structural damage. Repair guidance criteria and additional alternatives clearly are needed. One set of rules will not fit all situations.

Very few locations are totally free from exposure to natural hazards. Most locations are exposed to from two to several of them. Although it has been common to deal with hazards one at a time, it generally would be wiser to adjust to all natural hazards present. At least one Federal agency is mobilizing to define coordinated responses to some of the more spectacular natural hazards. Hopefully, their pioneering concepts and efforts will be able to address the full range of natural hazards.

Identification of potential natural hazards obviously is prerequisite to their avoidance or mitigation. In practice, identification of natural hazards often is largely a matter of chance. Could a coordinated hazards identification effort be mounted on a national scale? Who would benefit? Would the returns from investment in such an effort be as great as from comparable investments in other hazard mitigation alternatives?

Individuals consider natural hazards, if at all, in different ways. Individual viewpoint often is a function of involvement, including cost-sharing involvement. The public's compassion increasingly has finite bounds, especially toward those who deliberately and repetitively rely upon compassionate cost-sharing for assistance. Some view risk from the standpoint of "caveat emptor" while others think a public agency should protect the consumer, whereas a rational approach is somewhere between those extremes.

Local officials have a different viewpoint. They generally lack legal authority to police natural hazards on private property, except to the

extent the hazards may affect the public health, safety or welfare. Few harrassed public officals will step beyond their clear authority and insist that the individual, on his private property, adjust to natural hazards. And most city officials would be uncomfortable with a broadened legal authority. They have sufficient hot potatoes. Like code enforcement. Which hasn't worked consistently yet.

State governments clearly could provide vital leadership toward natural hazards mitigation, if States had the motivation and the resources. Between financial problems and ever-changing pressures on Statehouses, strong State leadership typically has yet to emerge. State governments are sympathetic to those who suffer losses, but States nonetheless tend to view local hazards as local problems. States usually serve as the catalyst to secure Federal assistance for their impacted communities.

The Federal government, although it tends to assume an ever-increasing natural disaster tab each year, has had little authority to require or enforce natural hazard loss mitigation measures. It clearly is aware of continuing disaster assistance drains on the Treasury and probably is acutely aware of the potentials for larger drains (perhaps three to ten times as large) in the event of great natural disasters. As man does not control the timing of natural disasters, it seems prudent to limit their impacts lest they compound the Nation's economic and social problems at a critical time. Some natural hazards losses are tax-deductible, further straining the Federal Treasury by reducing income tax revenues. Executive

and legislative leadership perceives the economic threats from natural hazards and is striving to encourage more active State and local loss mitigation roles. The National Flood Insurance Act of 1968 provides some such encouragement and is becoming an effective tool, although much remains to be accomplished.

There clearly are differences in motivations, responsibilities and economic burdens among the various interests affected by natural hazards. There clearly is a need for initiatives and incentives that will help motivate responsible individual, local and State efforts to achieve natural hazards loss mitigation. The Federal exposure to potential natural hazards losses may be so great as to justify superimposition of natural hazard loss mitigation requirements on local codes. But first, appropriate requirements must be devised and tested.

Recent unpublished studies suggest that past hazard exposure decisions of individuals often may have been more justifiable, economically, than heretofore has been supposed. It is now evident that the characteristics of natural hazard exposures often may be at least as significant as the frequency of exposure. This argues for significant changes in present policies.

The 1965 Task Force on Federal Flood Control Policy perceived the futility of offering natural hazard insurance unless it's implementation assured substantive flood loss mitigation efforts. The National Flood Insurance Act of 1968 retained that essential relationship by establishing compliance with flood loss mitigation objectives as a prerequisite for local eligibility

for flood insurance. Some recent proposals for "all hazard" insurance have not incorporated similar precautions. The Insurance industry unquestionably has a potentially important role in the formulation and implementation of natural hazards policies, but theirs certainly is not an exclusive role. Who else should be involved? How?

The Insurance industry perceives limitations upon the total amount of all-hazard coverage it should write. Those limitations may relate to the difficulty of accumulating reserves, or of liquidating extensive reserves quickly.

Reexamination of regulatory objectives and policies relating to natural hazards is in order. Reexamination of natural hazards loss mitigation options and opportunities, considering the entire spectrum of natural hazards, is an essential input to consideration of natural hazards objectives and policies. Heretofore underemphasized considerations (such as environmental and value considerations) of themselves justify a fresh look at natural hazards objectives and policies. Policy is seen as a fundamental rationale providing bases for individual and corporate decisions and for decisions at all levels of government.

From the practical standpoint, all-hazard insurance poses some difficult problems. The fast-acting spectacular disaster is easily recognized and its damages may be appraised readily. Insidious, creeping natural hazards losses, such as expansive soils damages, may be difficult to identify and their damages may be difficult to appraise. Although expansive soils may

be present, observed damages may be due to other causes. Professional evaluation of claims often would be necessary, and damages and claims might continue for years on a given site. The Insurance industry lacks appropriate mechanisms for handling insidious, creeping disasters, but if they are not covered, all-hazard insurance will fall short of its promise and will cover only about one-half of the natural hazards losses to real property.

As of today, the Insurance industry has no simple standardized procedure for adjusting insurance rates where loss mitigation measures are instituted for an individual property. Adjustment methodology is needed.

Disaster relief and assistance presently is available for victims of extensive spectacular natural hazards, but not for victims of less extensive or non-spectacular natural hazards or those whose impacts are insidious. The individual's loss and suffering fundamentally is neither ameliorated nor aggravated in proportion to the number of his neighbors similarly impacted. Compassionate assistance should be equitably and consistently available to all victims of uninsurable natural hazards regardless of the scale of the disaster.

Disaster assistance presently is funded largely by special appropriations. Funding needs are irregular over time and special appropriations often carry "add on" provisions that preclude consistent assistance response policies. A national fund, with continuing income and consistent disbursement regulations may be appropriate for presently uninsurable natural hazards losses.

The concept of "disaster prevention" by protective works construction is deeply entrenched. "Protection" may obscure a hazard and encourage unwise occupancy. It often should be an interim or stopgap measure, to buffer a hazard until wiser adjustments to it may be evolved and implemented. The concept of "Protection" should be broadly and realistically reexplored. Past "protection" has focused essentially on flood hazards. Billions of dollars have been spent for flood protection, although flooding causes only a small part of the Nation's total natural hazards losses. A building exposed to flooding also may be exposed to potential losses from several other natural hazards, perhaps more significantly than to flooding.

Extension of governmental assistance liability without concurrent requirements for hazard avoidance or mitigation actions encourages adverse occupancy, potentially burdening the economy appreciably more. *Liability for assistance should not be extended without adoption and enforcement of sound hazard avoidance and mitigation policies.*

Few properties are exposed to only one natural hazard. It generally would be wise to explore potential hazards and evaluate consolidated avoidance or mitigation alternatives prior to land use or construction decisions. Identification of hazards and alternative adjustments to them is the essential first step toward reversing the trend of natural hazards losses.

The present range of implemented hazard avoidance or mitigation alternatives is limited. Much greater variety is possible. In a given situation, dynamic implementation of several alternatives may be far more appropriate

than implementation of a single simplistic static solution. Redefinition of hazard avoidance and mitigation alternatives, their interrelationships and their consequences, is needed.

Present responsibilities for natural hazard avoidance and mitigation actions are nebulous. There is no clear-cut loss reduction program. There now is a multiplicity of uncoordinated, limited, specific responsibilities and programs, which occasionally have conflicting objectives. A unified, coordinated approach to natural hazards avoidance and loss mitigation is essential. Response voids must be filled.

Present legal and institutional structures and objectives tend to discourage effective natural hazards avoidance and mitigation actions. Lip service alone will not correct a ten billion dollar annual loss into a ten billion dollar annual increase in productivity. Institutional arrangements that create conflicting objectives should be modified.

Policies that fail to differentiate among fully urbanized areas, partially urbanized areas, and raw land proposed for urbanization are outmoded and counterproductive. Alternatives and optimum responses differ among those area types. An array of policy and response alternatives should be defined for existing land uses, proposed new land uses and transitional areas.

Some potential natural hazards losses can be significantly reduced without increasing initial construction costs. They can be reduced even more with only moderately increased initial construction costs. There is no clear-cut responsibility for development, promulgation or implementation

of such technology, but existing institutions could implement it. Development and promulgation of practical and improved loss avoidance and mitigation technology, and standards, should be someone's primary responsibility. Once developed, all institutions should make use of it.

Simplified methods for rapid identification and quantification of exposure to natural hazards should be developed. Many costly and lengthy past studies have generated findings having no greater reliability than do existing quick approximation methods. A hard look at the productivity and reliability of entrenched evaluation methodology would be appropriate. We might accomplish much more, with comparable reliability and in a more timely fashion, with little increase in cost.

Motivation toward natural hazards avoidance and loss mitigation is proportional to the certainty of loss and the magnitude of the direct economic liability of the interest involved. Motivation is essential for action. Individual interest group policies obviously will vary in accordance with their motivations. It is unrealistic to expect broad support for one set of policies among all interest groups. Many policies and initiatives obviously are appropriate.

Potential flooding damages to the typical American home can be reduced about 75% by increasing the initial cost of the home a few hundred dollars. But such flooding damages can be reduced nearly 50% without increasing the home's initial cost. Should building regulations automatically require damage—mitigating construction that can be accomplished without increasing cost?

Damage mitigation through "floodproofing" largely consists of appropriate selection and use of materials and appropriate location and layout of mechanical and electrical components. Those same types of approaches also could be applied successfully to reduction of potential damages from earthquakes, high winds, tornado fringe winds, and differential soil movements of various kinds. Does this suggest an integrated approach to natural hazard loss mitigating construction? What should be considered in evaluating justifiable added construction cost?

As most construction is exposed to some natural hazard and few properties are exposed to only one natural hazard, at what degree of risk should there normally be a transition from dependence upon structural protection or loss mitigation measures to sole reliance upon insurance? What considerations are appropriate in defining that degree of risk? Should it be a transition point or a transition range? Why?

Is the insurance industry geared to write "All Hazard" insurance, covering all of the basic 25 to 30 significant natural hazards? Are there ways they could avoid adverse selection? Could insurance be used as an incentive to natural hazards loss mitigation actions or would it encourage inaction? Are there alternatives?

Could the insurance industry develop sufficient reserves to respond promptly to maximum credible claims? Or even to maximum probable claims?

What constraints do limitations on reserves accumulation place upon total endorsed risk? In the event of a great disaster, would there be potential secondary displacements caused by reserves liquidation?

What should be the role of the Federal government? In past major disasters, it has absorbed a large share of the total losses. Could it doso in the event of a maximum credible or maximum probable disaster tomorrow? What would be related impacts upon the economy? What would be the social impacts of such disaster?

Is there a "maximum acceptable" disaster loss? (Defining acceptable as the maximum level of loss which could be sustained without permanent adverse economic and social consequences for the Nation). Would definition of a maximum acceptable loss level define the extent of essential loss mitigation actions?

Federal disaster assistance is a direct economic burden. Its peaks are random and somewhat unpredictable as to demand level. Could a trust fund be used as a leveling device? How might a trust fund be administered to avoid potential secondary impacts similar to those that would follow massive liquidation of private insurance reserves?

At present, post-disaster action and financing responsibilities largely devolve upon the Federal government. Can that load be redistributed so that States, locales and the citizenry most directly involved will react more responsibly? Are new mechanisms for responses, keyed to various response need levels, promising for redistribution of responsibilities?

Past Federal roles (other than flood control) have focused essentially upon post-disaster relief and reconstruction. Federal efforts expended to encourage or achieve land use consistent with hazard avoidance and practical damage-resistant construction might also be worthwhile. Could such a program be aimed at about a 60% to 70% reduction in urban natural hazards losses over about a thirty year period, at a reasonable operating cost? How?

States and locales increasingly have relied upon the Federal government for disaster assistance, but they have not concurrently strengthened their own disaster prevention roles. Their needs ideally should place as small an added burden as possible on the Federal government. In our governmental system, is it reasonable to expect local and State officials to adopt and enforce meaningful land use and construction controls? Is there a maximum practical level of local response, even with Federal incentives, that should be recognized? If so, how can it be identified?

Is it possible to integrate the operation of all Federal programs to insure consistency with natural hazards avoidance and loss mitigation objectives?

Would a Federal building code, covering a limited number of items and superimposed on all local building codes, have merit for natural hazards loss mitigation? How could it be administered and enforced?

Some locations exposed to natural hazards have potentially significant values for environmental protection or enhancement. Some examples would be flood plains, swamps, beaches and estuaries. Should they be used for desirable open space for the American population? Shouldn't environmental protection and enhancement operate hand-in-hand with natural hazards avoidance and loss mitigation?

"Protection" as usually considered is for the long-term. But shorter-term protection may be more justifiable economically. Regular but small losses may be more significant than rare great losses. Are we selecting protection and occupancy levels realistically?

The actual amount of natural hazards losses can only be estimated coarsely, as losses are poorly documented. For example, average annual flooding losses are "officially" estimated at slightly more than one billion dollars, but there are indications that they actually exceed two billion dollars. As another example of the uncertainty of damage statistics, the "official" damage estimate for one subdivision impacted by the 1971 San Fernando Earthquake was $58,600, but more careful examination and estimates revealed at least $600,000 direct damage within the tract with perhaps an equal amount of consequential follow-on damages foreseeable. The true extent of natural hazards losses is uncertain but clearly is significant.

Responses to natural hazards often have been in proportion to their individual <u>average</u> annual damages, but statistical averages may obscure

important considerations. As an example, average annual flooding losses have been from ten to twenty-five times greater than average annual earthquake losses this century, but potential sudden earthquake losses might be five to twenty times greater than losses from the largest foreseeable flooding event. The potential national impact of such a great disaster argues for thorough reevaluation of everyone's land use and construction policies.

No city in the United States has authority or responsibility to control the full scope and array of natural hazard concerns. Some cities effectively control some of them. Statutory enablements of municipal powers do not provide cities basic authority necessary to control all conditions on private property that are the basic source of a large proportion of natural hazards losses. Loss mitigation policies must recognize the constraints on local authority, and that few local governments desire their removal.